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PUBLISHED MONTHLY FOR THE ADVANCEMENT OF THE SCIENCE AND ART OF WELDING

New-

OXWELD NO. 28 COLUMBIUM TREATED 18-8 WELDING ROD*

for better welds in *Stainless Steels* . . .

• The new Oxweld No. 28 Columbium-Treated 18-8 Welding Rod (patent applied for) has been made for welding titanium- or columbium-bearing stainless steels of the austenitic chromium-nickel type. It also should be used for welding untreated stainless steels.

Oxweld No. 28 produces sound welds of great strength which have all the advantages of the original stainless steel. Both the weld and the adjacent zones remain fully corrosion-resistant.

Linde engineers will gladly cooperate with you in adapting proper welding procedures to secure the maximum advantages of Oxweld No. 28 Columbium-Treated 18-8 Welding Rod. This service is available from Linde Sales Offices located in thirty principal cities throughout the country and at 30 East 42nd Street, New York, N. Y.

PRODUCT OF A UNIT OF UCC UNION CARBIDE AND CARBON CORPORATION

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*Patent Applied For.

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Unit of Union Carbide and Carbon Corporation

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Construction and Repair by Arc Welding

By A. F. DAVIS*

Steel Pipe, Arc Welded, Saves in Cost of Building New Water Line

Large savings on a new water supply line were recently made by the city of Tacoma, Wash., when it used steel pipe arc welded instead of concrete construction. Added to savings in construction, arc welded steel pipe provides greater strength, longer life and greatly reduced maintenance.

The new line extends through hilly country (see Figs. 2 and 4), and is approximately $2^1/_2$ miles in length. It is part of a 10-mile line which conveys water at reasonable low pressures from the source of supply to Tacoma.

Three sizes of pipe—52-inch, 58-inch and 63-inch diameter pipe—were used in construction. The pipe was fabricated and joined entirely by shielded arc welding. The line was welded in sections of 300 to 3000 feet, depending on the terrain.

The pipe used is all $^5/_{16}$-inch wall thickness. Forty-two hundred feet of the line are 52-inch diameter, 7500 feet 58-inch and 1350 feet 63-inch.

Approximately 900 feet of the line rest on concrete piers to which the pipe is anchored as shown in Fig. 3. This 900-foot section was butt welded with 4-inch H-bar butt strap welded on each side as shown in Fig. 1. Expansion joints were placed in the line at intervals of 450 feet.

All welds were tested hydrostatically, stressing the steel to 18,000 lb. per sq. in. The line was welded by the Puget Sound Machinery Depot, Seattle, Wash. The pipe was fabricated by the Birchfield Boiler Co. of Tacoma.

* Vice-President, The Lincoln Electric Company.

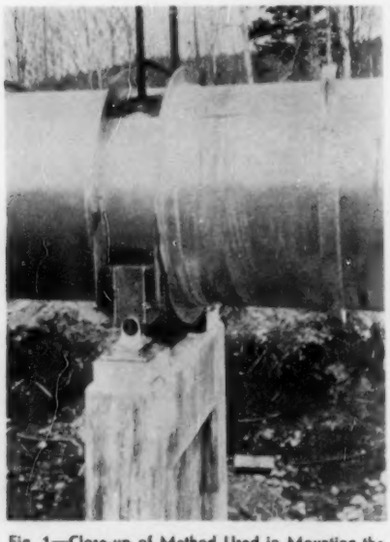


Fig. 1—Close-up of Method Used in Mounting the Steel Pipe on Piers in Construction of New Tacoma Water Line by Arc Welding. Photo Shows Angles Attached to Rocker Support

Fig. 2 (Top)—Along the New Tacoma Water Supply Line. The Steel Pipe, in Addition to Being Joined in the Field by the Electric Arc, Was Entirely Fabricated by Arc Welding

Fig. 3—Part of a 900-Foot Section of the New Welded Steel Tacoma Water Line. This Section Was Butt Welded with 4-Inch H-Bar Butt Straps Welded on Each Side

Fig. 4—Lower End of the Rhode Lake Section of the New Steel Water Main Welded Electrically by the Shielded Arc Process for the City of Tacoma, Washington

Fig. 5—New 45-Foot All-Welded Tug Beaver State, Built Entirely by Shielded Arc Welding for the Great Lakes Dredge & Dock Company by the Manitowoc Shipbuilding Company

New All-Welded Tug Enters Service on the Great Lakes

Two new all-welded tugs were recently delivered to owners by the Manitowoc Shipbuilding Company, Manitowoc, Wisconsin. One vessel was constructed for the Great Lakes Dredge and Dock Company and one for the L. A. Wells Construction Company.

Figure 5 shows the tug Beaver State delivered to the Great Lakes Dredge and Dock Company. This vessel is 45 feet long over-all, 11 feet 10 inches beam, 6 feet 3 inches molded depth to lowest point of shear, 4 feet 9 inches extreme draft and 2 feet 6 inches minimum freeboard. As shown in the illustration the Beaver State is an unusually trim-looking craft for this type of vessel. Her hull is welded into one integral piece of steel and is stronger than a conventional vessel of the type. Yet it is of lighter construction.

An interesting feature of the vessel is the assembly of the deck house and pilot house into a single integral unit. This one piece construction permits easy removal of the entire unit to provide ready accessibility for engine installation or removal.

Deep Sea Diving Equipment Arc Welded Aids in Treasure Hunting

A fortune of $100,000,000 lies on the ocean's floor, waiting for someone to recover it! This immense treasure is known to exist—even its location is charted. Some of it has been recovered. Some has been brought to the surface, only to break loose from salvaging cables and plunge back into the deep.

Laden with a reputed $4,000,000 of army gold, the British Frigate Hussar, buried for more than a century under the mud of Hell Gate, New York, was raised 12 years ago, until its stern appeared above the surface. Its fortune was within reach of the salvors. But only for an instant! Before any of its yellow metal could be removed, the water-soaked hulk broke away and disappeared.

The past unsuccessful attempts to wrest vast fortunes away from the sea have been due to failure of salvaging equipment to withstand the intense pressures encountered in deep-sea operations.

The latest equipment which has proved successful in deep-sea treasure-seeking operations is shown in accompanying illustrations. The diving bell, shown in Fig. 6 and the monster diving suit shown in Fig. 7 were used in bringing to the surface from a depth of 218 feet, the safe of the liner Merida, supposed to contain the great rubies of Maximillian, executed emperor of Mexico.

The diving bell illustrated is used by the director of operations for watching the progress of divers in salvage work.

Fig. 6—Diving Bell, Designed by Capt. Harry L. Bowdoin, and Constructed Largely by the Shielded Arc Process of Electric Welding. The Shell Thickness is 1 Inch

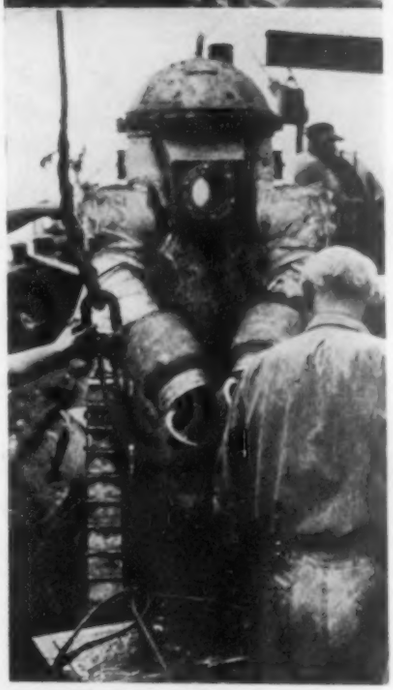


Fig. 7—Diver's Suit, Built of Steel Arc Welded, Has Tractor Treads for Feet, Huge Clumsy-Looking Appendages for Arms, Steel Mitts for Hands, Pincers for Fingers

Fig. 8—Constructing the Steel Shell of the Diver's Suit with the Electric Arc

Fig. 9—Another View of the Construction of the Steel Shell of the Diver's Suit with the Electric Arc

The bell accommodates three men. Its shell is constructed of steel plate 1 inch thick. Construction is as strong as it is possible to make it. In order to develop the full strength of the steel, the shielded arc process of electric welding was used to fuse the heavy steel plate into one integral unit. Portlights, air manifolds and other parts are arc welded.

As shown in Fig. 6, the diving bell is equipped with propellers for moving it into position. These propellers are covered with a steel protective shield welded to the bell.

The monster-like diving suit shown in Fig. 7 is welded throughout except for removable parts. Figures 8 and 9 show construction of the suit's steel shell by the electric arc.

The tractor treads, visible in Fig. 7, are really the feet which enable the diver to move about on the ocean floor. The awkward looking arms become effective appendages under the high pressures encountered in deep water. Steel mitts enclose the diver's hands. Through them, he operates steel pincers for gripping objects.

The arms of the suit have been developed after years of testing many different types. Former arms operated satisfactorily at low pressures but the squeeze of deep water made them useless. The arms could be raised to a certain point—that of lowest cubic content—then pressure would hold them powerless.

The arc welded steel diving suit has demonstrated freedom of movement to depths of 218 feet. Divers claim it will be effective to depths of 700 feet. The increased range of operation, provided by the equipment, opens the way to the recovery of huge treasures which in the past have been unapproachable.

Both the diving bell and suit illustrated are from designs by Capt. Harry L. Bowdoin, prominent salvaging authority. The welding on both pieces of equipment was done by Thomas S. Finney of Norfolk, Virginia.

Largest All Welded Hospital Ship Is Delivered to Owner

The largest of its type ever constructed by arc welding, and one of the largest all welded vessels ever built, has just been delivered by John H. Mathis Company of Camden, New Jersey, to St. John's Guild of New York City.

This vessel (see Fig. 10) is a floating hospital 181 feet long, 49-foot beam and 11-foot moulded depth. Accommodations are provided for 1550 passengers and crew. Classification is by the American Bureau of Shipping. The ship is of fireproof construction and built throughout of arc welded steel to the most modern design. The hull is divided into 25 watertight com-

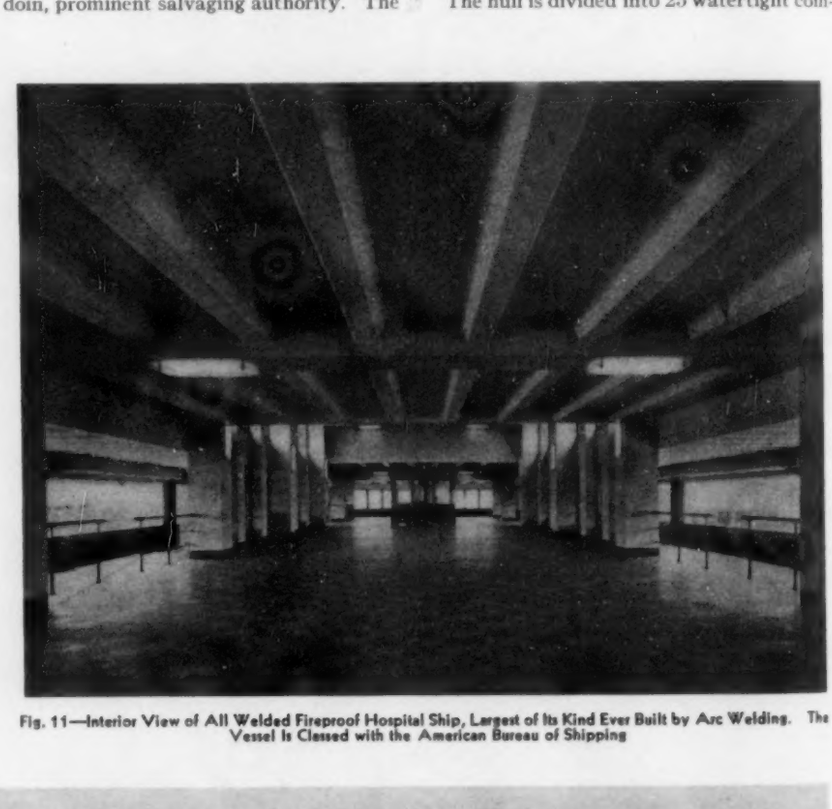


Fig. 11—Interior View of All Welded Fireproof Hospital Ship, Largest of Its Kind Ever Built by Arc Welding. The Vessel Is Classed with the American Bureau of Shipping

Fig. 10—Floating Hospital Ship Constructed Entirely by Arc Welding and Just Delivered to St. John's Guild, New York, by The John H. Mathis Company, Camden, New Jersey

partments and has three decks, one of which is shown in Fig. 11.

The use of arc welding in building this vessel allowed the builder to employ bent plate construction. Only a very small percentage of shapes were required. This type of construction provided many advantages, including stronger connections of hull members, reduced weight, absolutely watertight compartments, lower construction costs, concealed piping and wiring and complete drainage due to elimination of rivet heads and flanges. According to the builder, the vessel will also cost less to maintain since it is virtually one single piece of steel. Moreover, the accommodations of the vessel can be increased simply at any time due to readiness with which new additions can be made by arc welding.

Approximately 90,000 linear feet of welding was required in building the vessel. The speed of construction with arc welding can be appreciated from the shortness of time required to build the vessel. The keel was laid September 29, 1934, the vessel was launched April 6, 1935 and delivered to the owner late in May.

Machine Performs Six Distinct Operations in Fabricating Transformer Cooling Tubes

An ingenious machine which performs six different operations is used at the Pittsburgh Plant of the Allis-Chalmers Manufacturing Company, in the fabrication of radiator tubes for transformers.

This machine, shown in accompanying illustrations, takes strip steel, presses a series of grooves into it, folds it over, crimps the two edges, welds them together and then cuts off the welded tube into proper lengths.

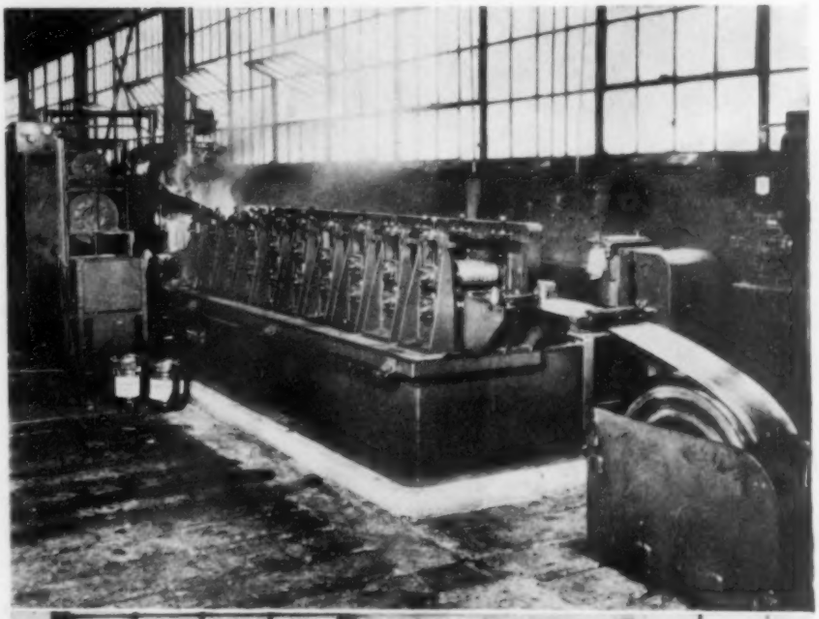
Operation of the machine is entirely automatic. The machine turns out a 12-foot tube every 1.2 minutes. This high fabricating speed is made possible by the automatic shielded carbon arc process of welding.

As shown in Fig. 12, strip steel $9^{5}/_{8}$ inches wide, 16 gauge, is drawn into the machine. This strip passes between rollers which press six grooves into it. The grooved strip is then folded over the edges crimped. The formed tube then passes under the carbon arc (see Fig. 13) which welds the edges together. The welded tube emerges from the machine in a continuous piece. A saw, which travels in the same direction and at the same speed as the tube, cuts off the correct lengths—5 to 10 feet long, as required. (Fig. 14.)

A completed half radiator composed of 20 tubes is shown in Fig. 15, mounted in a welding jig. This half radiator is 12 feet long by 3 feet wide by $5^{1}/_{2}$ inches deep. Other sizes range from 5 to 12 feet long. The half radiators weigh 50 pounds for each foot of length.

As shown in the illustration, the flat tubes are welded by the manual shielded arc process to pipe at either end of the radiator. These pipes serve the purpose of holding the tubes rigidly in place and carrying the cooling oil which circulates through the tubes.

Fig. 12—An Automatic Machine Which Takes Strip Steel, Grooves It, Folds It Over, Crimps the Edges and Welds Them Together by the Electronic Tornado System of Automatic Carbon Arc Welding



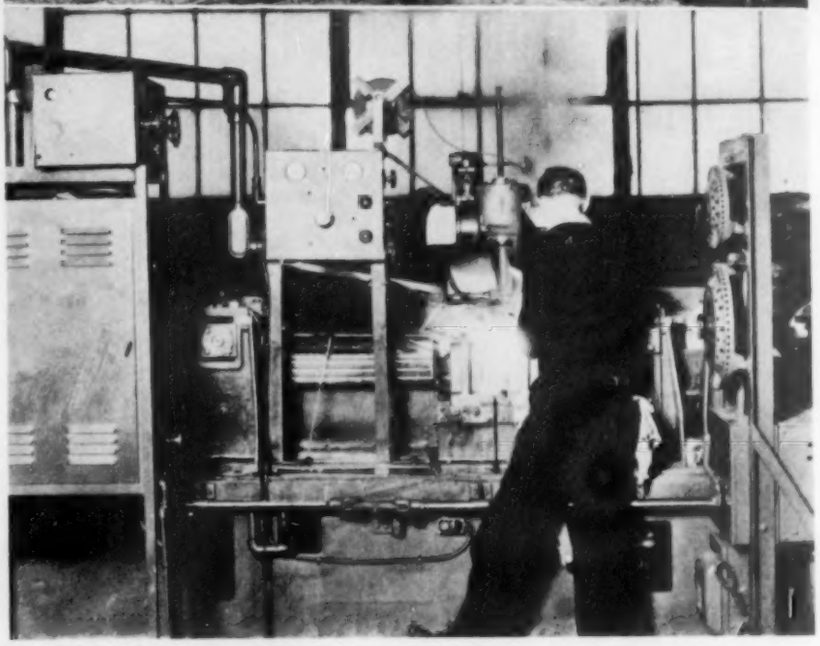


Fig. 13—As the Metal Strip, Which Has Been Grooved, Folded Over and Crimped, Passes under the Carbon Arc, It Is Welded Together at the Rate of 10 Feet Per Minute

The automatic shielded carbon arc process of welding known as the Electronic Tornado system was used in fabricating these radiator tubes. The Electronic Tornado utilizes a controlled atmosphere around the carbon arc which prevents oxidation of the weld metal. This system of automatic carbon arc welding provides great savings in fabricating costs where large numbers of products of uniform character are manufactured. It is being used extensively in the automotive industry, in the manufacture of many parts, also in the manufacture of large pipe, steel barrels, tanks, metal cabinets, barges, etc.

The application of the Electronic Tornado to the particular machines illustrated and described herewith was developed by the Allis-Chalmers Company in collaboration with our Company.

New Welding Manipulator Reduces Handling Costs

A welding manipulator, which permits positioning all work to be welded so that fillet welds of correct radius can be made without waste of electrode metal, and which permits savings of 25 to 40 per cent in welding time alone, is announced by the United Engineering and Foundry Company, Pittsburgh, Pennsylvania. In addition to reducing welding costs and improving the quality of work, this manipulator

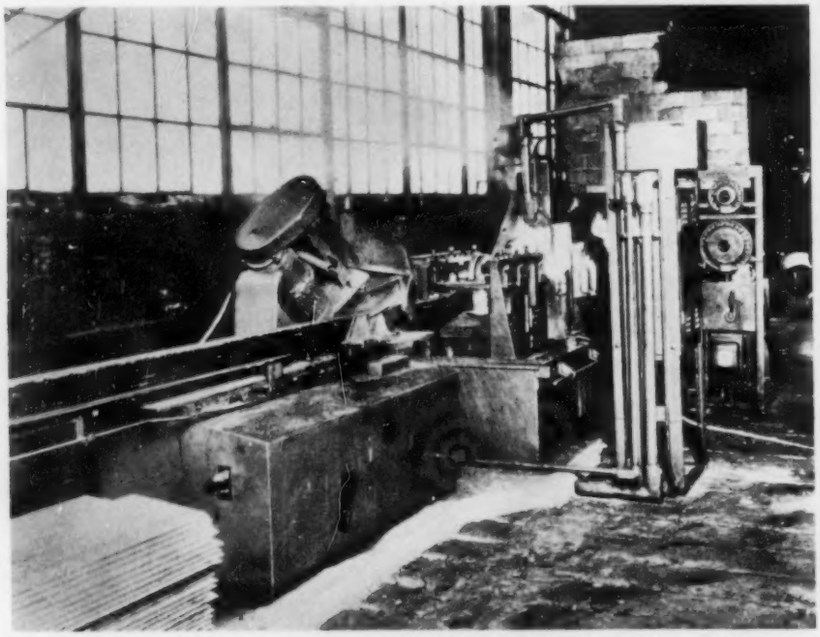


Fig. 14—The Welded Tube Emerges in a Continuous Piece. A Saw Which Travels with It Cuts the Tube into Proper Lengths for Transformer Radiators

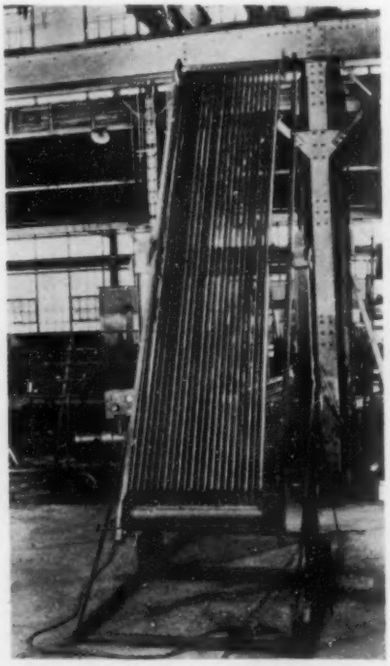


Fig. 15—One Half a Transformer Radiator Composed of 20 Tubes Automatically Welded by the Electronic Tornado System. Oil Circulates through the Tubes Dissipating Excessive Heat. A Complete Radiator (40 Tubes) Consists of Two of These Sections Welded Together

frees the overhead crane for other duties and eliminates the riggers which are necessary for crane handling.

The welding manipulator, shown in accompanying Fig. 16, is portable and in general consists of a face plate operated by power supplied by an electric motor. Operation of the electric motor is controlled by push buttons mounted on an extension cord. By pressure of the proper control button, the face plate can be tilted or rotated to any desired position, the operator riding with the work (see Fig. 17). Only two handling operations are necessary when using the welding manipulator. These consist merely of placing the work on the face plate for welding and then removing it after welding is completed. Ample provisions for mounting the work are readily available in the face plate.

Capacity of the manipulator illustrated is from 5 to 7 tons, depending on the center of gravity of the work being handled. Actual figures covering reduced welding costs by use of the welding manipulator, also a copy of a pamphlet entitled "Management of Welding Costs" can be obtained by application to the United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

Electric Arc Saves Cleveland Bridge Badly Damaged by Corrosion

Ten thousand dollars were recently saved the City of Cleveland, Ohio, when the badly corroded stringers of a 50-year old bridge were strengthened by arc welding, according to Paul Simon of the Ohio Machine & Boiler Company, the concern which repaired the bridge.

This bridge, which spans the Erie railroad tracks at East 34th Street, Cleveland, Ohio, was damaged by heat and corrosive elements discharged from locomotive smokestacks. The stacks clear the bridge stringers by only 6 inches and the corrosive agents had practically eaten through the stringers.

Only by the electric arc process was it possible to repair this bridge without prac-

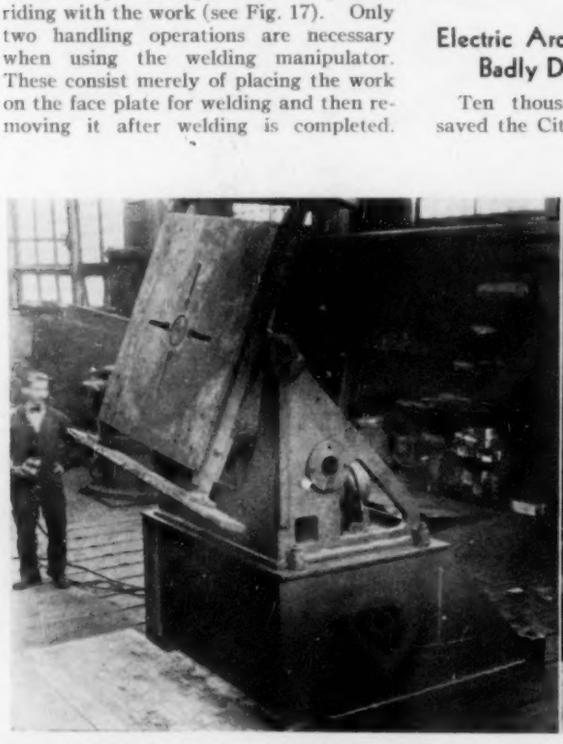


Fig. 16—Reduced Welding Costs and Higher Quality Welds Are Made Possible through Use of This Portable Welding Manipulator Developed by United Engineering & Foundry Company, Pittsburgh, Pennsylvania

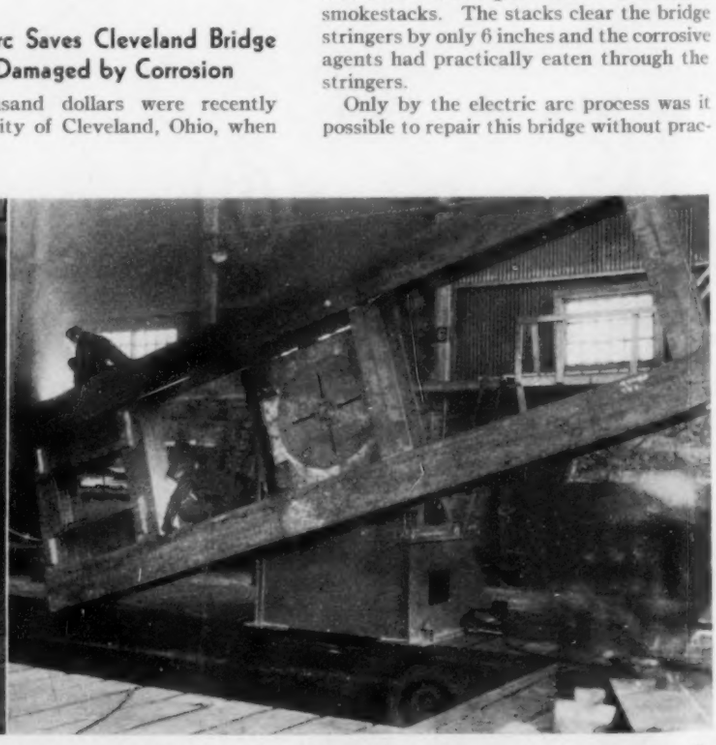


Fig. 17—New Welding Manipulator Can Be Tilted or Rotated to Any Desired Position. The Welding Operator Rides with the Work and Obtains Proper Positions by Means of Push Button Control

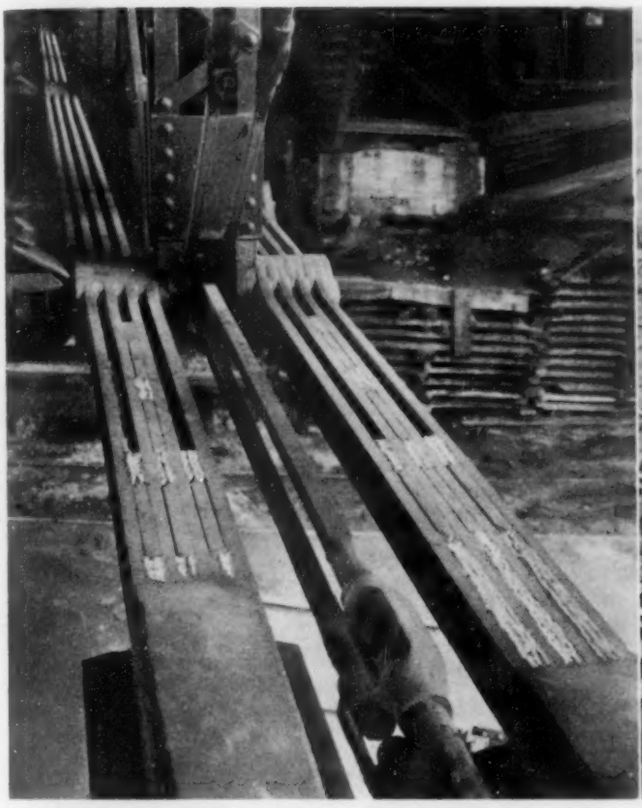


Fig. 18—Stringers of East 34th Street Bridge, Cleveland, Repaired by Arc Welding after They Had Become Badly Corroded by Smoke from Locomotive Exhausts

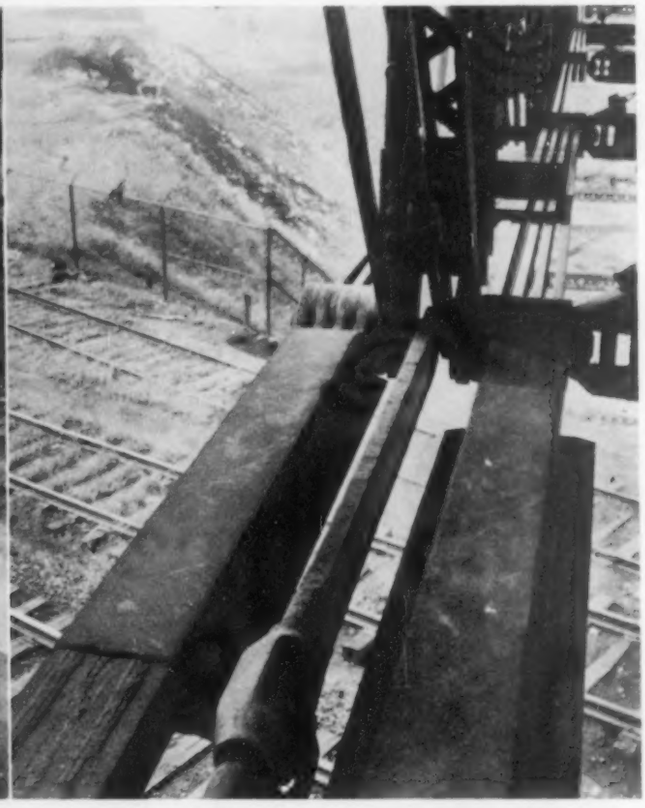


Fig. 19—Smoke Plates Welded to Top and Bottom of Cleveland Bridge Stringers to Protect the Repaired Portions from Further Corrosive Action

tically dismantling it and erecting extensive falsework beneath to support the structure while repairs were in progress, stated Mr. Simon, in commenting on the economical advantages of arc welding. The accompanying illustrations offer graphic explanation of the method and manner of the repairs to the span.

Old, badly corroded portions of the stringers were chipped away to expose sound metal. Lengths of steel plate were then inserted between the stringers, welded in place and the openings filled in with weld metal (see Fig. 18). After welding up the stringers, smoke plates were welded to the top and bottom to protect the stringers from further corrosion (see Fig. 19). A total of 500 feet of welding was required. It consisted of 200 feet of overhead welding (on the underside of the stringers), 200 feet of downhand welding (on the upper side) and 100 feet of miscellaneous work.

Work on this bridge was seriously handicapped by passing trains. In order to prevent accidents, it was necessary for one man to stand by and warn the welders (who did the work from ladders), of approaching trains. So great was the force of locomotive exhausts that welding cable, wire brushes, etc., had to be tied down. In spite of these obstacles, the bridge was open to traffic at all times and the work completed ahead of scheduled time.

This bridge was repaird for the department of bridges and docks of the City of Cleveland. The bridge, as far as the stringers are concerned, is stronger than ever.

Thermit Fells Skyride Tower in Forty-Two Seconds

By MERRITT L. SMITH†

WHAT the Ferris Wheel was to the Columbian Exposition in 1893, the Skyride was to a Century of Progress in 1933 and 1934. Consisting of two 3,000,000-lb. steel towers 628 ft. high, with a cable railway running between their tops, the Skyride furnished thrills for approximately 5,000,000 people during its two seasons of operation.

Since the close of the Exposition, the two tall towers of the Skyride have stood guard over the work of demolition and the wrecking of the east tower marked the final major operation in the removal of the structures of a Century of Progress.

In felling the westerly tower early in the summer, cutting torches and dynamite were employed. For the dropping of the easterly tower, however, a safer and less destructive method was sought and the use of Thermit to melt away sections of two of its legs was decided upon.

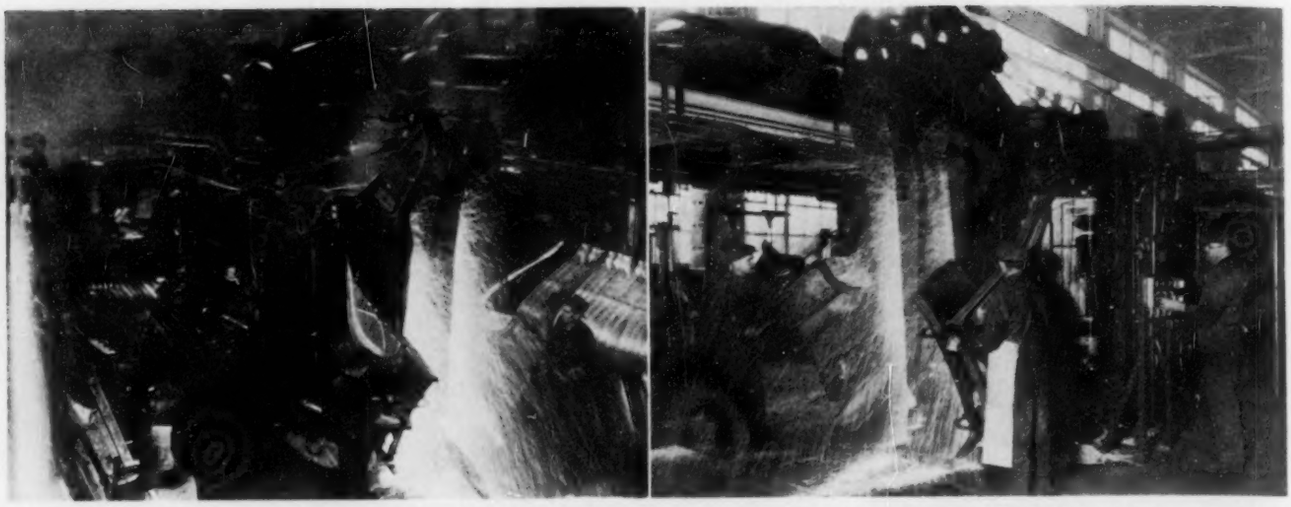
Each leg of the tower was made up of three I beams welded to form an H section.

Parts of the section of both of the two north legs were cut away by means of an oxyacetylene torch. The strips cut out were approximately 2 ft. in length and included part of the web of the web beam, as well as the inside flanges and portions of the webs of both flange beams. One point of cutting was near the base of the tower and the other point 10 feet higher on the same legs. The purpose of this preparation was to reduce the column section and lessen the quantity of metal to be melted by Thermit.

Four mold boxes lined with fire brick and sand were built around the columns at the points where the cutting had been done. Each of these mold boxes held 750 pounds of Thermit and each was fitted with electrical igniters.

Both of the north columns were cut and prepared with Thermit molds in this manner. (*Continued on page 19.*)

† Advertising Manager, Metal & Thermit Corporation.



These Huge Machines Weld Two 72-Inch Seams of the Ford V-8 Body in Seven Seconds. There Are Four of These Units in the Rouge Plant, Each 14 Feet High, Weight 28 Tons and Exerting Pressure of 2000 Pounds to the Linear Inch of Weld. Each Machine Has Six Transformers of 130 Kva. Each

Welding Operations on the Ford V-8

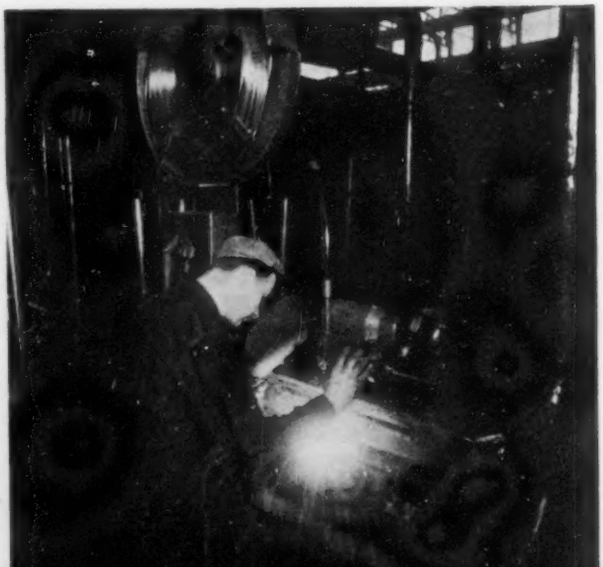
By DAVID P. CONNERY†

THE automobile, once assembled by means of bolts and nuts, rivets, nails and solder, is today largely a product of the welder. This applies especially to the Ford V-8, which on a recent check disclosed 3415 welds, with the number steadily increasing.

In making such an extensive use of welding, the Ford Motor Company has been obliged to design and build many of its own welding machines because for many of the operations there were no suitable machines available. Of the 3415 welds on a Ford V-8 Tudor sedan, 3154 were spot welds, 217 were electric arc or oxyacetylene and 44 were resistance butt welds. An extensive experimental department is operated at the Rouge Plant, Detroit, for the development and construction of transformers.

In the Rouge plant 5000 welding operations are carried on, five standard types of welding are used, and the equipment includes more than 1000 welding torches and over 600 welding machines. Most of the machines are automatic, controlled by synchronous tube timers which look a good deal like a radio set. A welding machine so controlled requires no skill whatever on the part of the operator, other than to put in the machine the part to be welded, and take it out after welding.

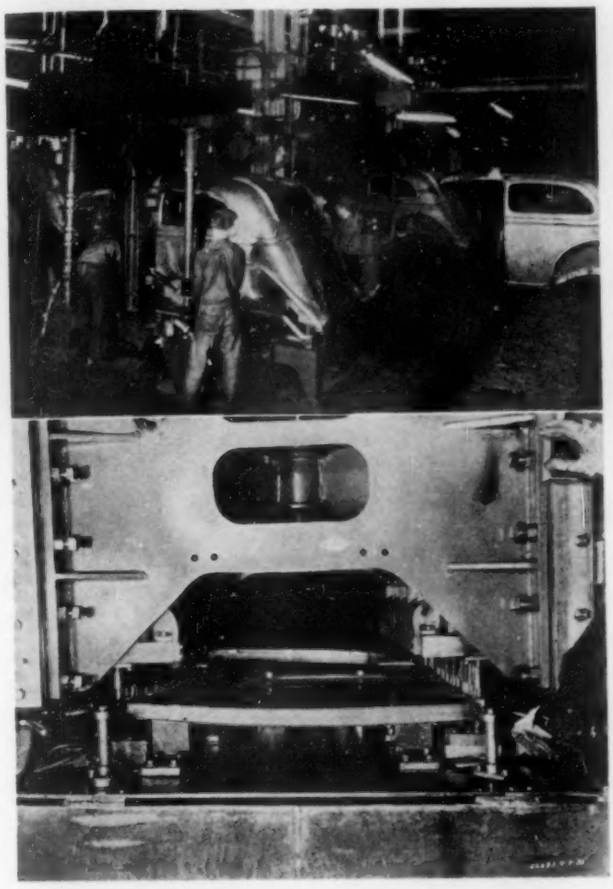
A new operation which has just been undertaken is in welding the outer panel of the automobile door to the door frame, to check movement and squeaking. Thirty-two spot welds make the panel and frame a single immovable unit, and the operation is performed by a Ford-built automatic machine. The door is placed in the machine, a button is pressed, a slide moves the door down into working position, then in a series of machine



Automatic Arc Welding of Axle Housing Seam

† N. W. Ayer & Son, Inc.

Butt Welding the Body in a Jig



Machine Making 40 Spot Welds in One Operation on Inner Door Panel

movements the 32 spots are welded, eight at a time. There are eight transformers in this machine, hung at the top of the machine instead of below it as is usual.

Most of the welding machines are in the Pressed Steel building, but each of the five tool and die departments has its own welding division. The Trade School has its own welding department.

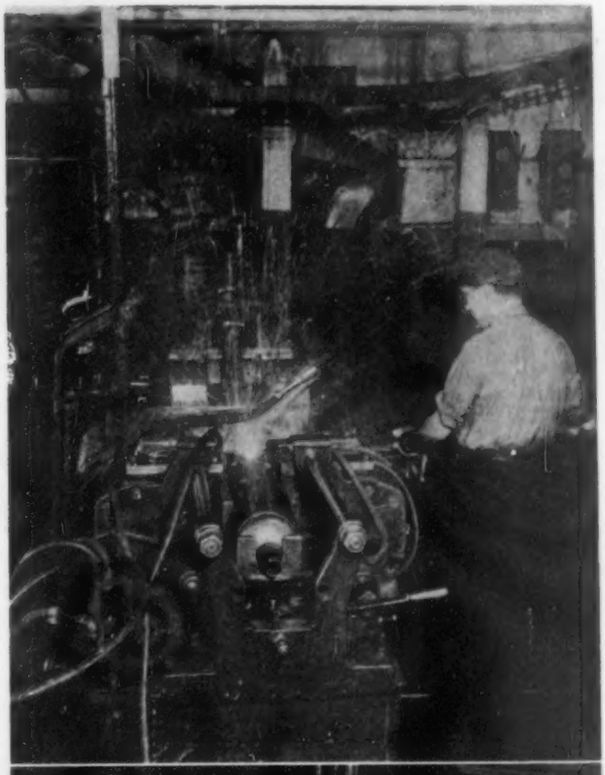
One of the most interesting welding operations in the Pressed Steel building is on the gasoline tank of the car. These were lockseamed and soldered in earlier days. About seven years ago Ford developed a method of seam-welding. The tanks are made in two halves, which are faced together and the edges welded down one side, across the end, back up the other side and across the other end. The tank welding machines are now being equipped each with a traveling carrier, an "Iron Man," which moves the tank to the various positions on the welding machine. The Iron Man operates on a low, flat-topped metal table and is moved by gears and chains while the welder runs the 102-inch seam in 90 seconds. There are eleven welded spots to the inch, making a watertight seam, which is proved by testing each tank in a nearby bath.

The front end of the body, which used to be largely riveted, is now entirely welded. The ventilator, pillars and lower panels are assembled to the windshield, upper header section and cowl section by spot and arc welding.

There are about 50 welding operations on a single door. The door frame's three sections are flash-welded together by four machines, each with a capacity of 300 per hour. Even the lock is welded to the door.

One of the most spectacular operations is the welding of the rear body assembly. The rear panel and two quarter panels are placed together in a huge "balloon" flash-welding machine, the operator pushes a button, the machine closes, and in a shower of sparks two 72-inch seams are welded in seven seconds. The four machines were designed and built by Ford, and are said to be the

Flash-Welding Operation on Muffler, Welding Intake Pipe to Muffler by Butt Process

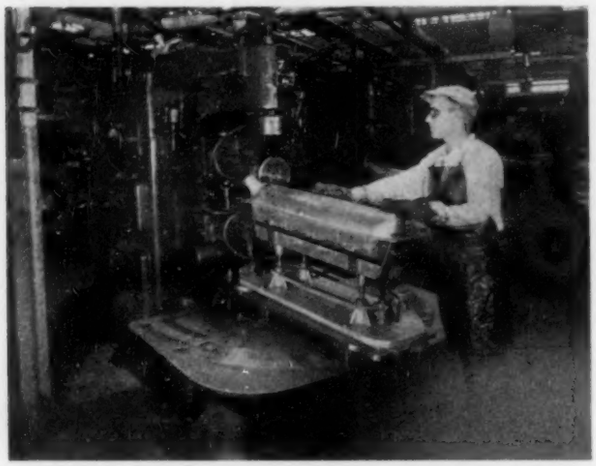


Automatic Welding of the Door Frame Into One Solid Unit, Eliminating Possibility of Squeaks in Use

largest welding machines ever made. The machines they displaced welded a 56-inch seam.

A difficult welding operation successfully used by Ford is in attaching the rear radius rod bracket to the rear axle housing. For this 12 double-head fully automatic arc welding machines are used, welding at a speed of 55 inches a minute. This weld leaves no skips at all. Few operators have succeeded in using the double-head arc in this way, and success has been achieved by eliminating the human element entirely. The time, pressure, power, quantity of wire, melting rate and other details are predetermined and automatic in these machines.

Until 1935 only the front radius rod of the Ford was welded. The rear rod was a formed tube, the ends of which were flattened and bolted into place. It was decided to weld the rear rod of the 1935 car to provide greater strength. This ran up the cost, so manufacturers of welding equipment and supplies were called on for better products to reduce the cost, and the Ford welding department went to work with them on the problem. Better generators and welding heads and faster-melting wire were produced, and the problem was solved.



Seam-Welding Gasoline Tanks on Automatic Machine, Showing the "Iron Man" Carrier. The Iron Man Carries the Tank While It Is Being Welded on a Course Shown by the Oil Marks on the Table. The 102-Inch Seam Is Welded in 1½ Minutes

The drive shaft of the car, which used to be solid and necessarily heavy member, is now a tube, reducing the weight losing strength. The shaft is arc-welded, the driving end being welded to the tube. This is an entirely automatic operation.

Over in the new steel mill where Ford is just starting the manufacture of body sheets and strips at the Rouge, an interesting spot welding operation is displacing the huge stitchers which ordinarily fasten the pieces of strip steel together so they can be wound on spools for easy handling and storage. The stitcher is a very large, complicated and costly machine, and involves a heavy loss of material because the strips have to be lapped two or three feet in stitching. All of the finishing strip mills in the new steel plant are being equipped with an automatic spot welder which fastens the strips together with 12 spot welds on a half-inch lap as the strip goes into the finishing rolls. The spot welder is small and comparatively inexpensive, and operates while the strip steel is moving through.

One of the potent reasons for the extension of welding operations in the production of the Ford V-8 is that welding permits of greater strength with less weight. Less weight involves less material, which means lower cost, and automatic welding also tends to reduce labor costs. It is one of the big reasons why it is possible to produce the present-day powerful, fast and durable car at a low price.

Oxyacetylene welding is very extensively used in the Rouge plant, but mostly on maintenance work. It is used notably for cutting out dies from plates up to 10 inches thick, and from forgings sometimes two feet thick. In production this type of welding is used chiefly for "tacking" operations on the body, especially in places which are hard to get at.

Statement of the Ownership, Management, Circulation, etc.

REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

OF THE AMERICAN WELDING SOCIETY JOURNAL, published monthly at Easton, Pa., for October 1, 1935.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and County aforesaid, personally appeared William Spraragen, who, having been duly sworn according to law, deposes and says that he is the Editor of the American Welding Society Journal and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Name of — Post Office Address

Publisher, American Welding Society, 33 W. 39th St., New York, N. Y.
Editor, William Spraragen, 33 W. 39th St., New York, N. Y.
Managing Editor, William Spraragen, 33 W. 39th St., New York, N. Y.
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2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

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3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)
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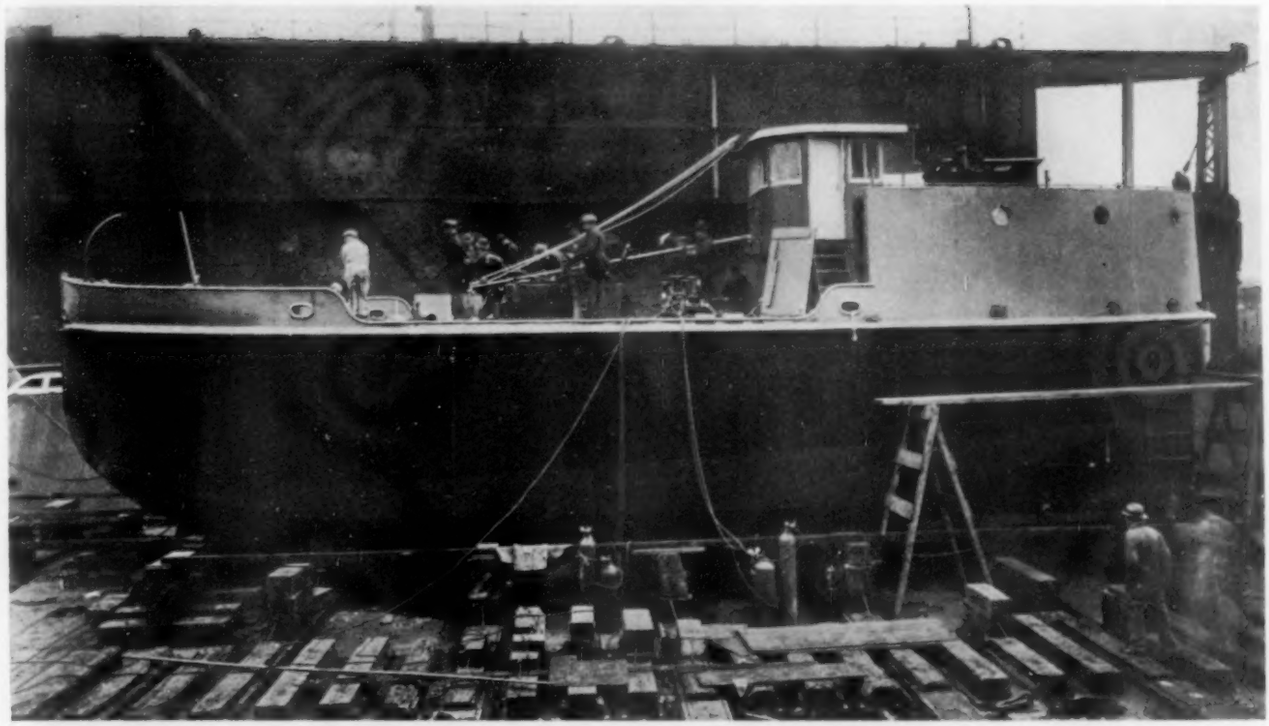
4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

W. SPRARAGEN, Editor.

Sworn to and subscribed before me this 27th day of September, 1935.

(Seal) MARY T. HICKEY
Notary Public, New York County Clerk's No. 138.
New York County Register's No. 6-H-316.
(My commission expires March 30, 1936.)



The M. V. STUDERUS 64 Ft. 7 In. X 21 Ft. X 10 Ft., 40,000-Gallon Tanker, Built by United Dry Docks, Inc., for Studerus Transportation Company, Kearny, N. J.

New System of Welded Ship Construction

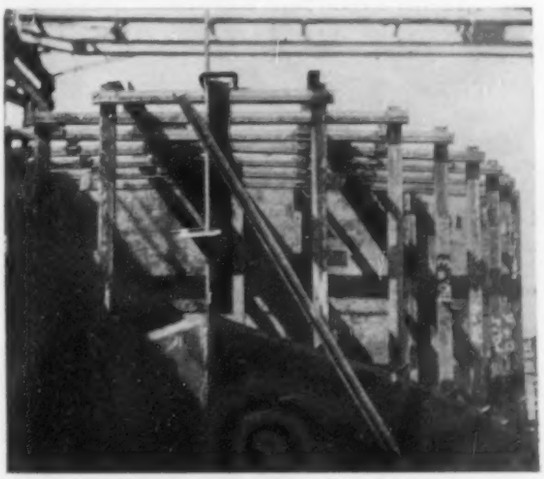
By R. D. MACMILLEN*

A NEW diesel-propelled oil carrier for Studerus Oil Co. of New Jersey, the first vessel of its type, is now being built at the Crane Twenty-Seventh Street plant of United Dry Docks, Inc., New York, to the highest class of the American Bureau of Shipping. With its completion, Johannes Kjekstad will have added a third, patented system of all-welded ship design to his truss-weld and reverse channel systems.

Free Flow Frame System

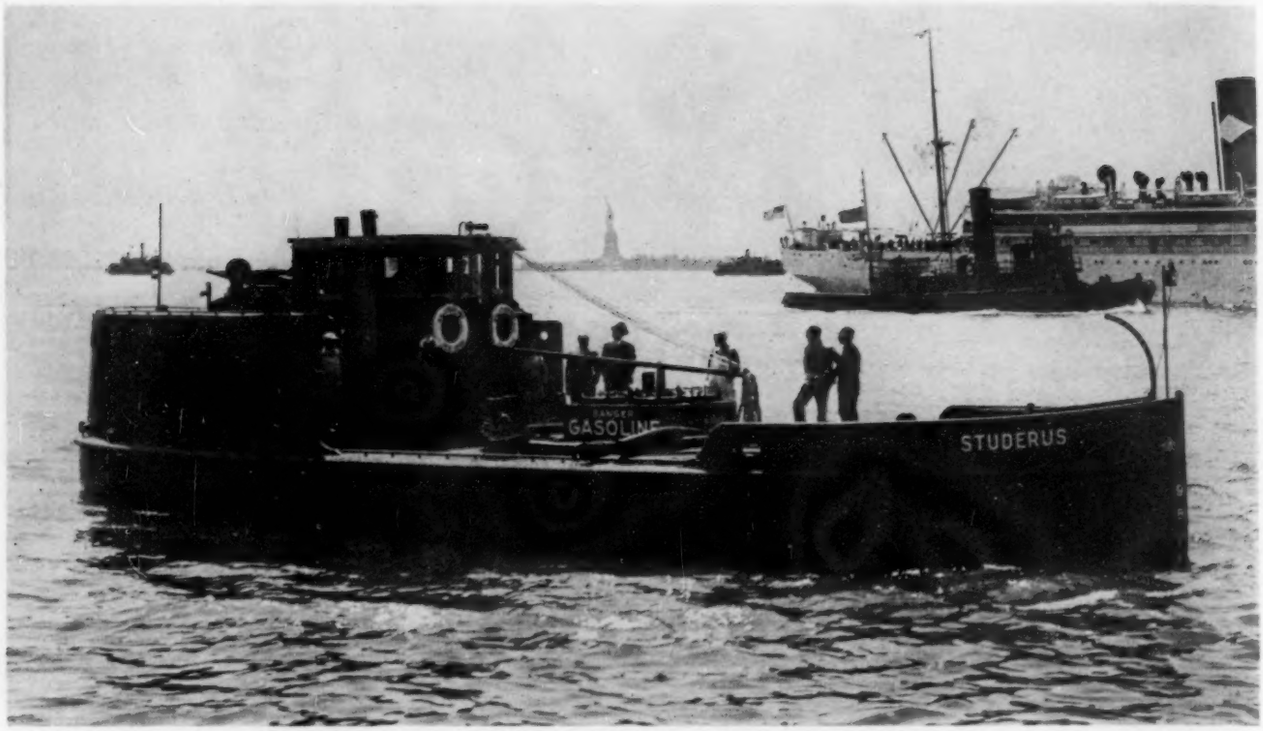
The "free flow frame system," as the new design is temporarily designated, achieves high structural efficiency, in inherent strength, flexibility and economy of material, as indicated by official tests made here and in Norway. The first tests were conducted last summer at the Staten Island plant of United Dry Docks, under the supervision of Messrs. Wilson and Walker of the American Bureau of Shipping. The results indicated that the new system has a 27 per cent higher structural efficiency against deflection and a 14 per cent less permanent set. Similar results were recently obtained by the Oslo Material Proveanstalt, a Norwegian testing institution, where a series of comparative tests showed that the free flow frame design is capable of sustaining a load 53 per cent greater than that sustained by a riveted frame of the same weight and a load 30 per cent greater than that sustained by an ordinary welded frame of like dimensions.

While the free flow frame system is well adapted to the construction of tankers and liquid cargo carriers generally, especially the larger hulls, its incorporation in any type vessel would seem to be fully justified by



All-Welded Bulk Oil Carrier under Construction on the New Free Flow Frame System

* Editorial Staff, *Marine Review*. (Printed with their permission.)



Vessel Is Powered by Twin Fairbanks-Morse Model 36, 60 Hp. 6-Cyl. Diesel Engines

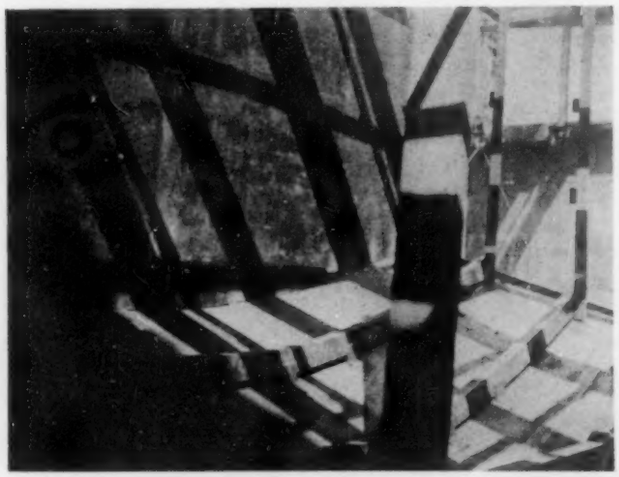
greater strength, lighter weight, and ease of maintenance, repairs and cleaning or painting

The new form of construction, according to the inventor, is "a system of 'open' framing in which the strength members are not directly attached to the shell plating, in the customary manner, but instead are so placed as to leave a space of some two inches between the outer edge of the frame and the shell. The effect of this 'open' framing is to increase the section modulus and the strength factors by placing the neutral axis of the frame shape at a greater distance from the shell plating; in other words, it operates to increase by so much the depth of the frames.

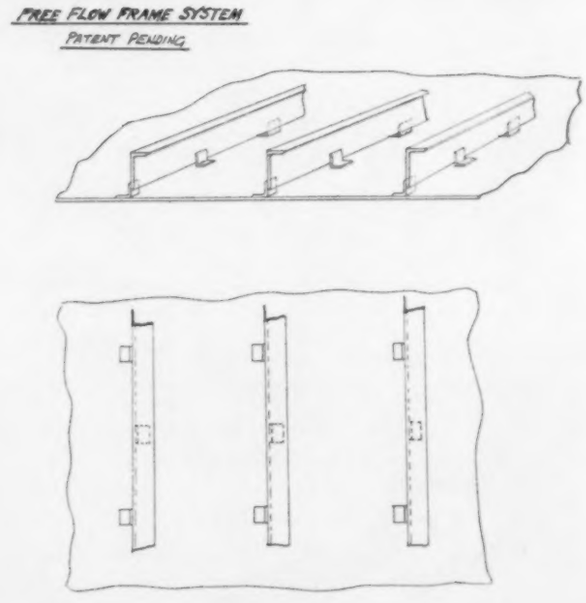
Saving in Weight

"When it is considered," the inventor continued, "that the weight of the frames, including beams and stiffeners, may represent as much as 30 to 50 per cent of the total weight of the hull, improvements in that part of the structure assume major proportions. Official tests indicate that there may safely be a reduction of about 20 per cent in the weight of frames and stiffeners, when attached in the manner specified in the pending 'free flow frame' patents. This saving, of course, may be utilized either in heavier shell plating, in lower total weight or in greater cargo capacity with the same displacement."

Greater strength and lighter weight, however, are but two of the important factors to commend the free flow frame design, Mr. Kjekstad pointed out. Valuable characteristics, from the production and maintenance



Framing Two Inches from Shell, Secured to It by Clips Welded at Intervals. Tanker Building at Crane Twenty-Seventh Street Plant, United Dry Docks, Inc., New York



points of view, also are disclosed by the tests conducted under American Bureau of Shipping supervision.

Obviously, detrimental stresses and distortions simply do not exist where the shell plating is heated hardly at all, because the welding area is confined to lugs, spaced at comparatively wide intervals. In the tests referred to above under American Bureau supervision the channel framing was two inches from plating and was connected to it by 4 x 4 x $^1/_2$ inch T-bar clips spaced 24 inches between centers.

In the matter of maintenance, too, the benefits are of a practical and attractive kind. Unlike the ordinary framing, continuously attached to the shell, the free flow frame system offers no hiding place for corrosion to start, no gas pockets, no sludge panels, no place that may not be easily and thoroughly cleaned or painted.

Easier to Repair

From the repair point of view, the free flow frame system affords distinct economies, it would seem: In the event of damage, either the plating or the framing may be repaired or removed, each without disturbing the other.

Details of the new design are shown to some extent in the accompanying illustrations of the bulk oil carrier under construction on this system for the Studerus Oil Co.

Report of Creep Tests for Gas Welded Steel†

(Low Carbon)

By N. F. WARD, M.M.E.*

Introduction

THESE tests were undertaken to determine the performance of cold rolled steel (0.09% C) and gas welded steel of the same grade under elevated temperatures at various tensile loadings. The first series of tests deal with the steel as received and welded and the second series of tests are reported for annealed cold drawn steel (0.09% C) and when this steel was gas welded and annealed.

These creep tests present the data for this particular steel. Obviously the extended period of such an investigation with indicated test equipment, precludes the consideration of steels of different compositions.

The approach to this research has been one of gradual development of data for design of welded equipment for elevated temperature service. With the absence of data for welded steels, the tests reported here are to be considered as preliminary to the investigation of the principal welded alloys.

Creep data on welded ferrous and non-ferrous alloys remains nebulous as far as the search of experimental records reveal. Undoubtedly, much experimental work is in progress and reports should be forthcoming. The designer who desires to incorporate welding as a fabrication tool in high pressure and elevated temperature service, has perforce, to resort to his own judgment because of the limited data which have been reported.[1]

Much pioneering remains to be undertaken in the field of creep in welded structures to widen the sphere of welding to metals in structures at elevated temperature. Of necessity the development of creep from the experimental standpoint is revealed by prolonged tests. Short

† Presented at Fall Meeting, AMERICAN WELDING SOCIETY, Tuesday, Oct. 1, 1935, in Chicago. Contribution to Fundamental Research Committee, American Bureau of Welding.

* Assistant Professor of Mechanical Engineering, University of California; Lecturer, Metallurgy and Welding, Boeing School of Aeronautics.

[1] Publication A-2, Edison Electric Institute, August 1933. Report of Prime Movers Committee.

Fig. 1—Photomicrograph of Resistance Heated Cold Drawn Steel

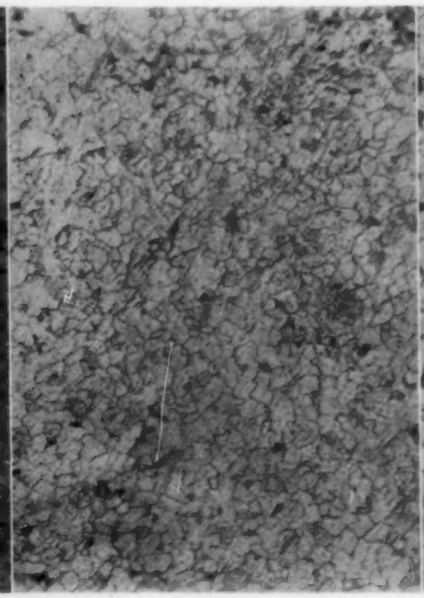


Fig. 2—Photomicrograph of Annealed 0.09% C Steel from 1650° F. Mag. 180 X

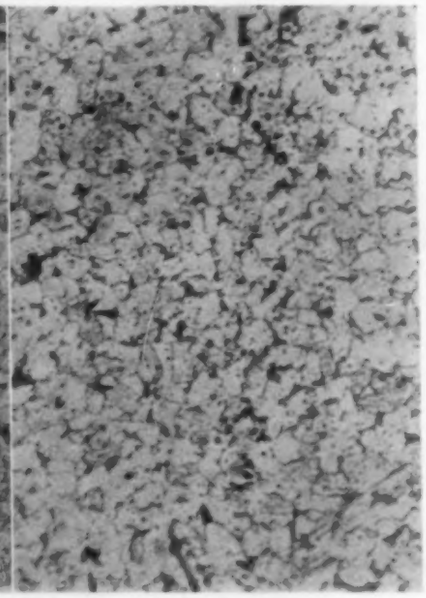


Fig. 3—Photomicrograph of Cold Drawn Steel. Mag. 180 X

time tests, while they are measurements of instantaneous creep, are a poor index for predicting performance at elevated temperature for any extended period of service.

Prolonged service tests become the only authentic record of phenomena of creep and these tests are the only bridge for the void between experiment and practice. Experience must still be relied upon to safely interpret creep data beyond the limits of test. It is the projection of creep values to include conditions of service 20 years hence, that the results remain of questionable scientific value. Only by correlation of data from various sources, both laboratory and field, can the mass of data be placed on a comparative basis. The pioneering efforts in this field must be correlated to yield useful results. Perhaps reluctance due to the expense of such investigation or lack of impulse due to insufficient number of creep failures, have delayed development of workable data. The record of the phenomena, as applied to welding, would be invaluable to the industry. By way of illustration, a welded unit with a tensile strength of 50,000 lb./sq. in. at atmospheric temperature is weakened at 1000° F., so that the tensile strength is 15,000 lb./sq. in. with evidence of creep or continuous plastic flow at 5600 lb./sq. in. which is 1% in 15,000 hours. Danger of fracture is very remote in this metal, since 15 to 17% elongation would be permissible before rupture should occur. For allowances of less than 1% to retain clearance and alignments and prevent distortion of shape, creep becomes the important criterion in design. For the lack of specific data the bulk of the parts must be increased to reduce unit stress; such design procedure for the present remains the only alternative.

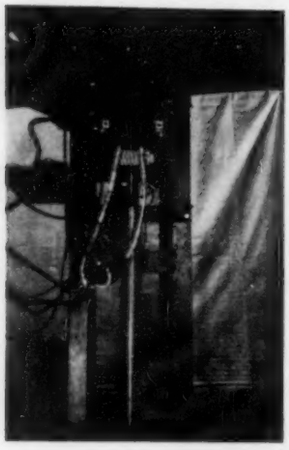


Fig. 4—Rear View—Specimen Loading Frame Furnace and Photographic Equipment in Position

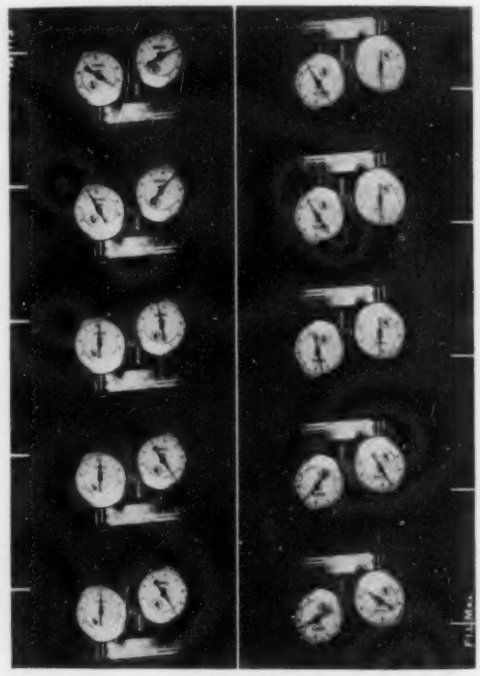


Fig. 5—Photographic Record by Hours of Creep Gaging Dials

The prediction of weld performance and the service and control of distortion in welded joints under creep conditions can be determined from suitable tests. These creep tests involve many variables, not present in unwelded metal. Briefly, these are:

1. Alteration in parent metal producing non-uniformity of metallurgical structure.
2. Inherent difference in resistance of fine and coarse grained metals.
3. Change in physical properties of parent metal and deposited metal.
4. Residual stresses of weld and parent metal.

Reduction of these variables to a quantitative basis appears to be most essential. There are two methods suggested: one by testing original metal and weld metal independently or testing welded joints deposited according to accepted practice for width of weld. The later procedure has greater possibility of yielding useful results for reliable joints under creep conditions. In the absence of or extensive outlay of test equipment, the procedure reported here approaches the requirements for actual service operation, by using comparative tests of

Table 1
Composition of Steels for Tests

Carbon	0.09 %
Manganese	0.38 %
Phosphorous	0.037%
Sulphur	0.033%

Physical Properties at Room Temperature

Steel Designation	Cold Drawn as Received	Cold Drawn Annealed from 1650° F.	Cold Drawn as Welded	Cold Drawn Welded-Annealed
Ultimate Tensile Stress, Lb./Sq. In.	103,400	70,000	48,000	42,000
Per Cent Elongation in 4 In.	3	17.2	3.27	15.6
Per Cent Reduction in Area	43	59	4.6	16.6
Hardness (Rockwell)	B-94	B-63.8	B-67	B-61.5
Modulus of Elasticity	26.2×10^6		27×10^6	
Coeff.[a] Thermal Expansion, In./In./° F.	71×10^{-6}	(68°–1000° F.)	67×10^{-6}	

[a] Values by Rockwell Dilatometer.

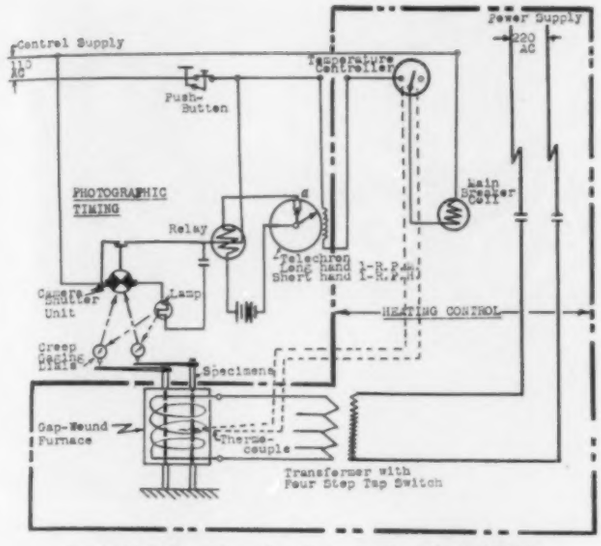


Fig. 6—Heating and Recording Circuits for Creep Tests of Welds

two specimens in tension, one being the original metal, the other being welded with the oxyacetylene flame according to accepted practice.

Details of Tests

Material: The material selected for the first creep tests was cold drawn 0.09% carbon steel with the physical properties appearing in Table 1. Selection of this steel in the cold drawn state and later in the annealed state in $^1/_4$-in. diameter was based upon the following considerations:

1. Uniformity of structure and physical properties.
2. Wide difference of properties in cold drawn and annealed state.
3. Effect of annealed condition upon creep resistance.
4. Minimum comparative alteration in deposited metal and base metal.
5. Possible data for welded stampings and rolled shapes.

Equipment for Tests: For purposes of description the creep apparatus is grouped under heating control of specimen, load and creep gaging, photographic record. These units in this experiment are considered in the order of their relative importance, yet these are the minimum of essential elements which have their indispensable place in tests of long duration. A degree of uniformity, usually absent with manual control, has been attained with the perfection of the automatic features in this creep apparatus.

Heating Control: Two specimens are heated simultaneously in a 1000-watt gap-wound electric furnace of elliptical cross section which is such that each specimen is positioned at the focal center of the elliptical cross section. To prevent over-heating of the specimens on the surfaces near ends of the major axis of the elliptical section, an additional refractory was added at these surfaces to reduce heat transfer of the furnace. A careful temperature survey of the two specimens in this furnace showed a maximum variation of 7° to 9° F. The hot junction of the thermocouple was placed against each specimen and enshrouded with a copper sheet to act as a holder and shield of each thermocouple.

An automatic temperature controller was used for these tests to regulate the temperatures at 350° F., 555° F., 998° F. The heating and control circuits appear in Fig. 6, where it is noted that "off-and-on" control for heating was used. The record of the temperature of each specimen was recorded periodically on a Brown recording potentiometer. A fluctuation of 20° F. in specimen temperature during the "on-and-off" position of the temperature controller was recorded on this potentiometer. This maximum variation of 5% of the lowest temperature at periods of 5 minutes was partially reduced by adjustment in tap switch setting and insulation at top and bottom of furnace openings. The effect of this periodic temperature variation did not appear to alter the properties of this steel probably since the fluctuation occurred well under the critical range of the steel.

Observation of Resistance Heating: As a means of rapid, uniform heating during "short-time" tensile tests at elevated temperatures the use of the specimen as a resistance element in the secondary of the transformer was

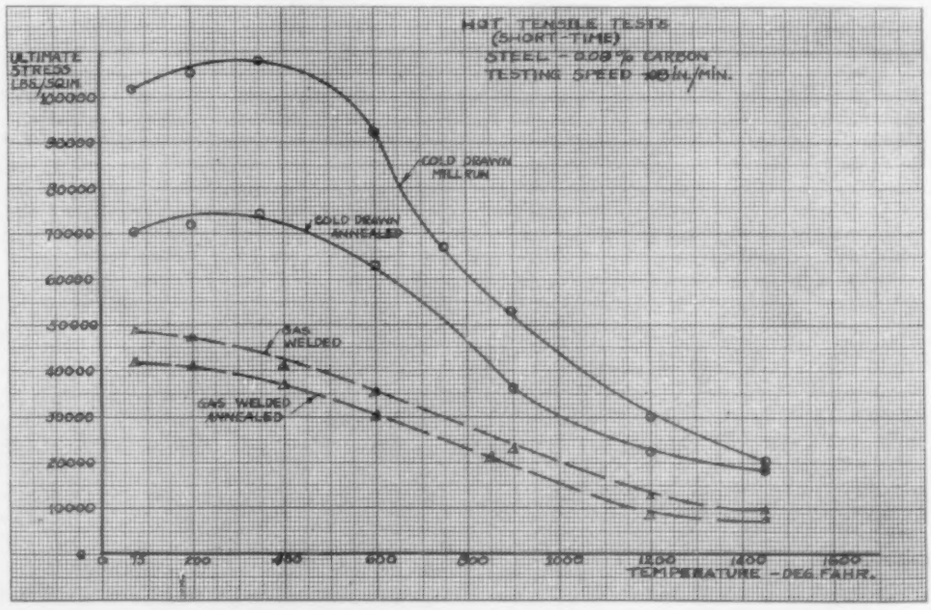


Fig. 7

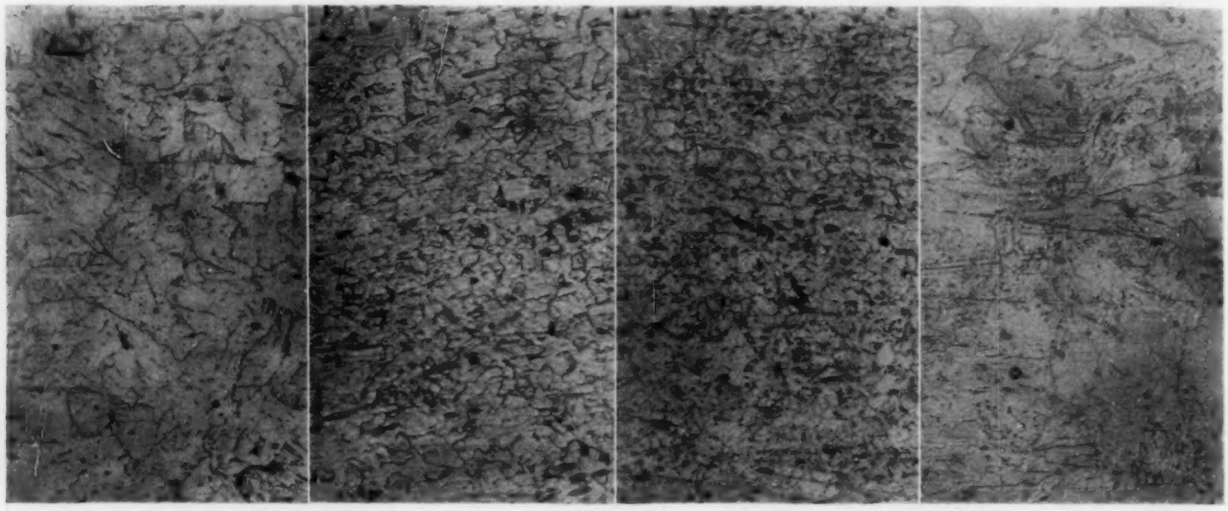


Fig. 8a—Photomicrograph in Gas Weld after Creep Test. Slight Excess Welding Heat Evident. Mag. 180 X

Fig. 8b—Transition Zone of Gas Weld after Creep Test. Position 1/2 In. from Weld Center. Mag. 180 X

Fig. 8c—Transition Zone of Fig. 8b after Annealing from 1650° F. Mag. 180 X

Fig. 9—Photomicrograph in Gas Weld-Annealed from 1650° F. after Creep Test. Mag. 180 X

considered[2] and actually used with following results. So long as the tensile specimen remained devoid of loading, temperatures of any magnitude were obtained up to the fusion point of the steel. Upon application of the tensile load the specimens lost their heat. In each instance the specimen retained a temperature of approximately 400° F. without increase after applying higher current inputs to the specimens, The fracture in each specimen when it finally ruptured was definitely blue.

That maximum temperature of 400° F. could not be exceeded under tensile stress is noteworthy in these studies. The cause appears to be the development of Stead's brittleness in which the electrical conductivity of the steel is definitely impaired. Apparently the phenomena of "blue brittleness" develops at the minimum temperature to complicate the phenomena. Figure 1 may be consulted for evidence of the structural change in the intercrystalline matrices of this steel heated in the above manner. The intercrystalline areas show eutectic melting and the crystalline matrix has undergone recrystallization without refinement at least to the degree attained by annealing with furnace heat as shown in Figs. 2 and 3.

It seemed inadvisable from these experiments to utilize resistance heating for the creep specimens in tension.

Specimens and Their Loading: Two specimens were used for each test. These were approximately 13 1/2 in. long and from 5/16 in. diameter of stock, the center section of each welded and unwelded specimens being turned to 1/4 in. diameter between fillets four inches apart in the test section. The machining of each specimen, especially those welded, showed by inspection the relative soundness of their condition. Each specimen was forged on the 5/16 in. end to engage a screw ferrule on its spherical bearing seat. The ferrules on both ends were then screwed in to the pulling head on one end and the stationary head on the underside of the furnace. (See Fig. 4.) The loading was applied with a suitable weight pan on the loading beam with its fulcrum 42 in. from the plumbline of dead weights, and specimen head was 3 in. from this fulcrum on the opposite end. Each specimen was loaded by its own weights in equal increments so that the loading of each pair of specimens was the same.

Blocking of the lower specimen head (see Fig. 4) to prevent relative movements of the lower end of each specimen and concentration of heat within the 4 in. plus fillet distance, localized the strain in the test section. The tests on these specimens with their ferrules in tensile testing machine showed that the measurable concentration of strain was in the test section. These smaller specimens reduce the bulk of testing equipment with some evidence of uniform behavior during test. But due to the similar mounting and loading, except for disparity of temperature of the two specimens, the experimental results should be comparable since any variation would be the same for each specimen in so far as each specimen is tested.

Creep Gaging: To register the creep of the welded and unwelded specimens, a rigid gage arm was strapped to each specimen on one end, and bearing on its creep gage, having $\frac{1}{10{,}000}$ graduation, at the opposite end. These were so arranged in focus with a slow moving picture camera which automatically photographed these two illuminated dials hourly. (See Fig. 5.) The developed positive film becomes the record of the creep of each specimen.

Operation of the Creep Tests Circuits: The review of the creep cycle is of interest in illustrating the procedure of these tests. The functioning of each circuit can be grasped by consulting Fig. 6. When the push button is closed the controller operates to close the power supply to the transformer and gap-wound furnace. When the temperature registered by the thermocouple in specimen furnace is less than temperature required, additional input may be adjusted by the tap switch on the transformer. Conversely, if the temperature required is in excess, the controller opens the main power breaker and shuts off the power to the furnace. Circuit contacts are made or broken every 20 seconds.

Operating simultaneously with the temperature controller is the photographic timing equipment. This consists of a telechron unit which at hourly or any interval desired at time of coincidence of the minute and hour hand energizes the relay, thereby lighting the Mazda lamps which illuminate the creep dials and energize the camera shutter motor. At the completion of its cycle in 20 seconds it de-energizes the relay, extinguishing the lamp and resetting for the next photographing cycle.

[2] Guy Verse, "The Elastic Properties of Steel at High Temperature," Transactions A.S.M.E., January 1935.

Failure of power supply or a lapse in photographic cycle is accounted for by a magnetic counter in this circuit. Each circuit is protected by suitable fuses.

Test Results: Short-time tensile tests were performed, since these serve to indicate the deformation during relatively short periods of time, and are summarized in Fig. 7.

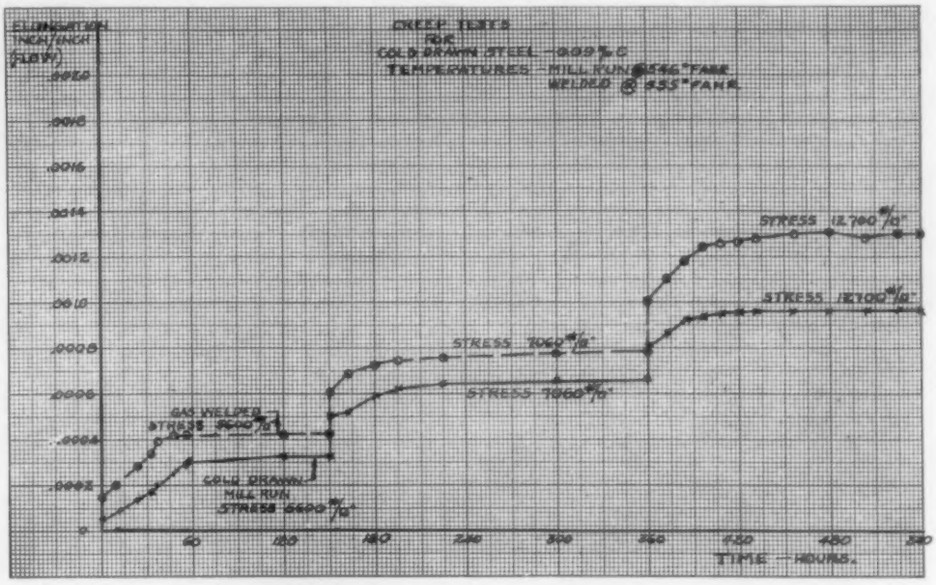


Fig. 10

The range of temperature for these tests includes from room temperature to 1450° F. The higher temperatures include the lower critical range and the best mechanical working range for this steel. The weld specimens appear to undergo less variation in tensile strength than the unwelded specimens for the rapid rates of testing encountered during these short time tests.

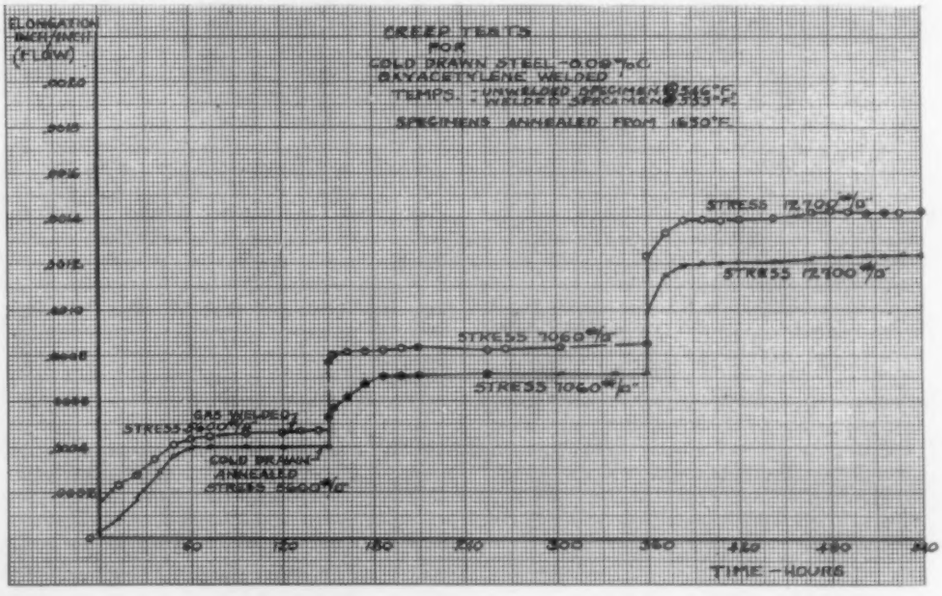


Fig. 11

This phenomenon is a function grain size and equilibrium between softening due to heat and strain hardening. The crystalline character of metals are recognized by tests on single crystals of aluminum and iron,[3] which

[3] Taylor and Elam, *Proc. Royal Society*, Vol. 102 (1923); Taylor and Elam, *Proc. Royal Society*, Vol. 112 (1926).

counteracts the strain hardening. Data[4] available indicate that softening proceeds at all temperatures, decreasing in rate with decrease of temperature so as to be negligible below certain temperatures.

This reciprocal phenomenon of softening under higher temperatures removes the strain hardening. If stress is maintained further slip will occur to create strain-hardening; otherwise the resistance to external load decreases. One could expect, therefore, that the creep rate would be dependent on the rate of softening of strain-hardened

[4] Bailey, "Note in Softening of Strain-Hardened Metals and Its Relation to Creep," *Jl. Inst. Metals*, Vol. 35 (1928). Pilling and Holliwell "Softening of Cold Worked Electrolytic Copper," A.S.T.M. (Now A.S.M.), Vol. 25 (1925).

metal. R. W. Bailey[4] has shown that the empirical laws for both under temperature are similar.

The mechanism of creep is not far removed from distortion at low temperature except in respect to time. Since no appreciable softening takes place at low temperature the distortion under constant stress is arrested by strain-hardening, whereas at high temperature softening offsets the gain due to strain-hardening. This change in equilibrium between the effects of softening and strain-hardening under elevated temperature is a manifestation of the increase or decrease of stress in metals. In these metals the decrease in strength of annealed or fine grained steel is more rapid than in the highly strain-hardened condition where resistance is decreased at higher temperatures by natural softening. The welded steel, while vitiated by welding heat is left with the large grain (Fig. 8*a*), which was only partially adjusted with annealing (Fig. 9) suffers loss in strength at elevated temperature. But this decline is less marked than in the cold drawn steel. The only basis for this behavior appears in the larger grained matrix. In the weld direct explanation is complicated by the varied microstructures which exist in the weld and the transition zone. (Figs. 8*b* and 8*c*.) For such large grained structure full stabilization of the gas welded structure can be effected by solution treatment and supplementary mechanical treatment.

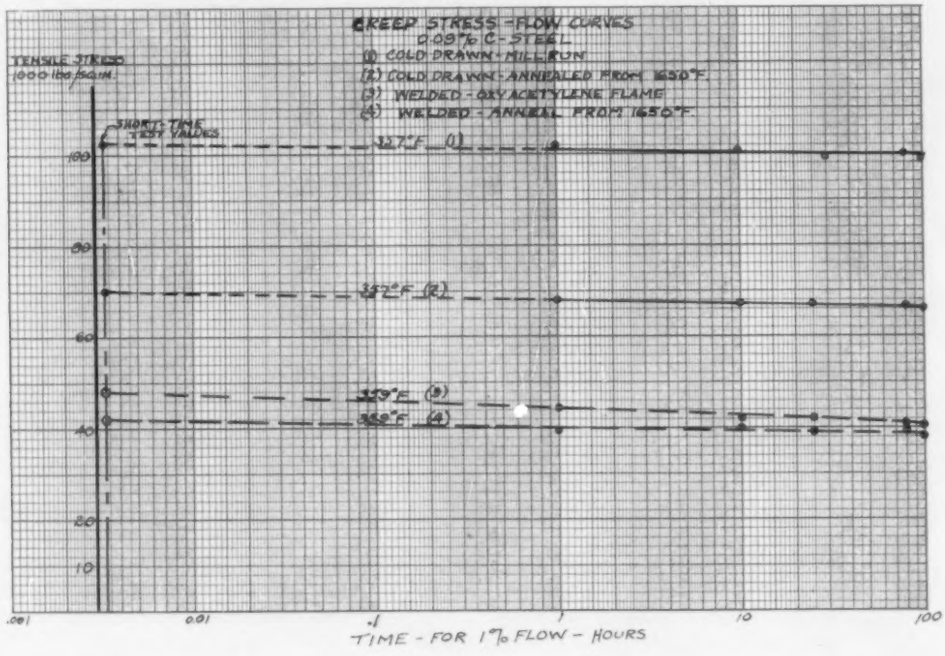


Fig. 12

Creep Data: For the long time strength tests, the results are plotted in Figs. 10–14. A log of the loading, unit elongation or flow for cold drawn and welded specimens appear in Fig. 10 for temperatures 546–555° F. The results for annealed specimens are given in Fig. 11. For other specimens, the temperatures of 350° F. (with

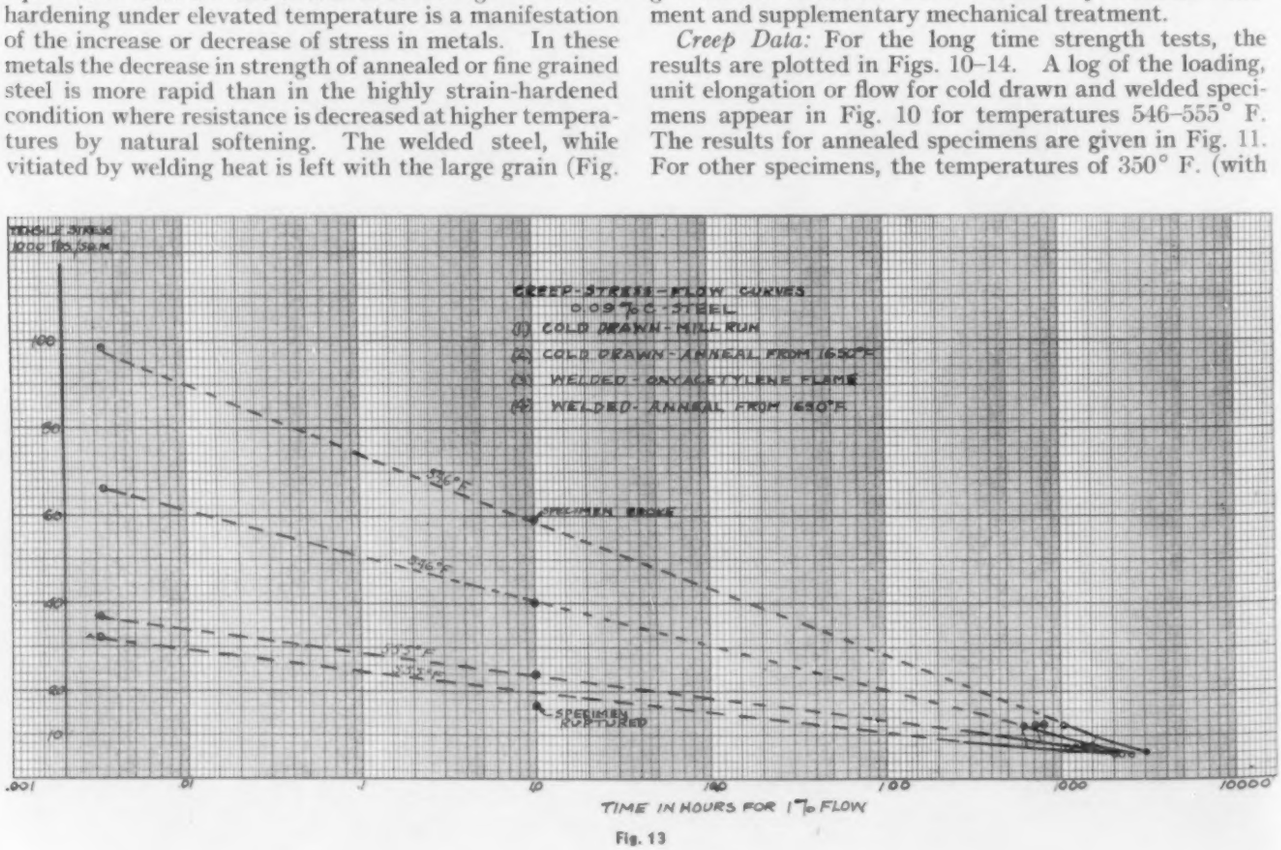


Fig. 13

7° to 9° F. variation) and 998° F. (subject to 7° to 9° F. variation), the data appear in Figs. 12 and 14.

For creep of original steel (0.09% C) and welded specimens of the same steel exhibit properties of flow under steady load which are closely in agreement, when data for 100 hours (Fig. 10) is projected to include the time which produces a flow of 1%. This extension of data assumes the rate of flow (unit strain at elevated temperatures) to remain proportional to that prevailing at room temperature. For example, the cold drawn will run according to data in Fig. 11, and reaches a steady flow rate of 0.00032 inch/inch in 100 hours. Or if these conditions of flow persist for a longer period, 1% flow (creep) would develop in 3100 hours. These interpretations are usual practice among creep investigators in the absence of very extended tests. For relatively low stress these long-time creep tests indicate only slight variations in creep, for the stress range 5600–12,700 lb./sq. in. at temperatures 546° F. and 555° F.

At higher temperature (998° F.) the creep characteristics of this steel in the cold drawn condition are more favorable than the welded steel. In fact, the welded low carbon steel shows a rate of flow at very low stresses, which would outlaw its use where creep was a criterion of design.

At lower temperatures the data is based upon specimens which were loaded to produce excessive stresses. Consequently failure was produced in a relatively short period of time which was of the order of 1 to 80 hours. The plot of this data upon semi-logarithmic paper produces comparatively linear curves. It has been upon this basis that the short-time test data has been included in the range of creep test data.

From the previous discussion of creep, short-time tests were shown to be creep tests for short intervals of time in which strain-hardening predominated with the resistance to loads of higher magnitudes than at elevated temperatures, where softening predominated with the attendant loss in strength. On this basis the data for short-time and long-time tensile tests have been included on the plots of the test data.

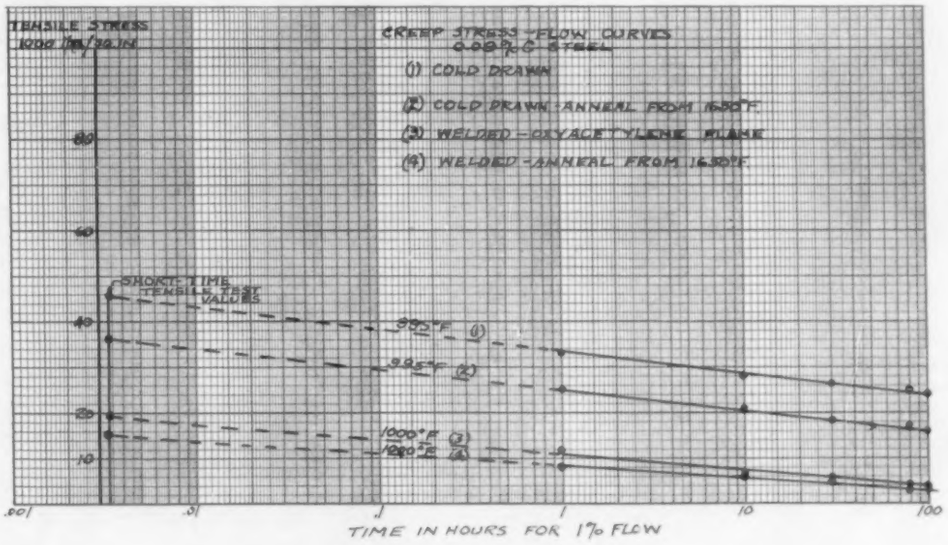


Fig. 14

Summary: The equipment for comparative creep studies of welded and original metal have produced sufficient evidence to show the performance of 0.09% C steel in the ranges of temperatures from 350–998° F. and tensile stress range of 5600–12,700 lb. per square inch.

For these specimens which were tested in the annealed condition a lower creep stress limit persists. The effect of annealing on this steel does not warrant its use as a means of improving its resistance to creep.

The creep stress limit as criterion in design is low for this grade of steel. For high temperature service its use is not recommended either in the original or welded conditions. For lower temperature ranges (200–400°) this steel develops excellent creep resistant properties either in the cold drawn or welded condition.

Acknowledgments: The author wishes to express his appreciation for the helpful suggestions and criticisms given during the course of these experiments by Dr. B. M. Woods and Mr. J. E. Gullberg.

Thermit Fells Skyride Tower

(*Continued from page 7*)

Before setting off the Thermit, the diagonal at the back of each of the north legs was cut through near the column base. Also, the two south legs of the backstay were cut and six-foot sections were removed from its two north legs, thereby preventing the backstay from interfering with the tower falling in the desired northerly direction. Two of the hold-down bolts in each of the south legs were cut off.

Before a crowd estimated at over 100,000 people, the Thermit mixture was flashed at 3 P.M. on August 30th. In a few seconds, the tremendous heat generated by the reaction had melted the steel at the points holding the mold boxes and the legs of the tower collapsed at these points almost immediately. The tower leaned slowly to the north, then gathering speed struck the ground with a terrific crash exactly forty-two seconds after the button was pushed to ignite the Thermit. (See Frontispiece.)

Resistance Welding of the Copper Alloys*

By IRA T. HOOK†

IN these days when light weight sheet metal is being given more and more consideration, the resistance welding processes have been accorded first rank as the method of making connections. While the greater bulk of sheet so used belongs to the ferrous group, there are numerous instances where copper alloys are advantageously used with resistance welded connections. Thus in the manufacture of copper alloy tanks and containers, in the assembly of innumerable types of electrical appliances, apparatus for the chemical industries, corrosion-resisting structural members and architectural assemblies, resistance welded copper alloys find many applications.

Several valuable papers have appeared recently in the JOURNAL, in *Metals & Alloys* and elsewhere on the fundamentals of resistance welding. In this discussion, however, we are interested chiefly in the results obtainable in the resistance spot and line or seam welding of copper alloy sheets. The data contained herein cover a period of investigation begun in 1930. In a sense it is a progress report since improvements are being made in resistance welding equipment and in new copper alloys adapted to show improved resistance welding performance.

Types of Resistance Welding.—While we are principally concerned herein with the resistance welding of gas tight seams in copper alloy sheet, some work has also been done with other types of resistance welding. In all of the work on copper alloys, we have found that the one requisite is that the metal be melted at the time the two parts are given their final push together. Straight resistance butt welding is, therefore, not well adapted to the welding of copper alloys.

Flash butt welding, on the other hand, offers a very good way of uniting rods, sheet edges and shapes. The metals are brought into contact with the current on and the consequent arc allowed to play across the faces until the metal is molten—in from a fraction of a second to perhaps 3 seconds—and the final push-up made *quickly* and *lightly*. It must be quickly to catch the faces while the metal is still molten and lightly in order to avoid too great an upsetting of the metal while it is in the hot short[1] condition.

As has been pointed out many times, the copper alloys do not possess a long pressure weldable temperature range similar to that of iron or low carbon steel. The latter becomes plastic for several hundred degrees before it actually melts. In this plastic condition welds in steel can be made by pressures in a rather wide range of intensity. With the copper alloys, this pressure weldable range, while the metal is still in a plastic state, does not obtain. The copper alloy must actually be melted to obtain a satisfactory weld. This fact, since the latent heat of fusion of the copper alloy is rather high, explains in a measure the high heat energy required to weld even the Everdurs.

The resistance butt and flash welding machines commonly built for welding steel usually do not have the light pressure and fast action that is needed for the successful flash welding of the copper alloys. There is no reason, however, why such skill cannot be built into a machine.

Resistance Spot and Seam Welding.—Where the metal is confined as it is in a spot weld or a seam weld, which is usually a series of spot welds from ten to twenty to the inch merging one into the other, the same conditions obtain, i.e., the metal must be melted and the push-up quickly and lightly made. Thus, the pressure between welding wheels should be very exactly controlled and the vertical guides for the movable spindle provided with roller bearings so that no part of the welding wheel pressure will be lost in friction. Various speed changes and various heat taps should be provided. The timing of

Fig. 1—Everdur Pillow. 5 In. Square, 0.040 In. Thick Flat Everdur Sheet Resistance Welded around Edges. Withstood 1000 Pounds Per Square Inch Hydraulic Pressure before Tearing at the Weld

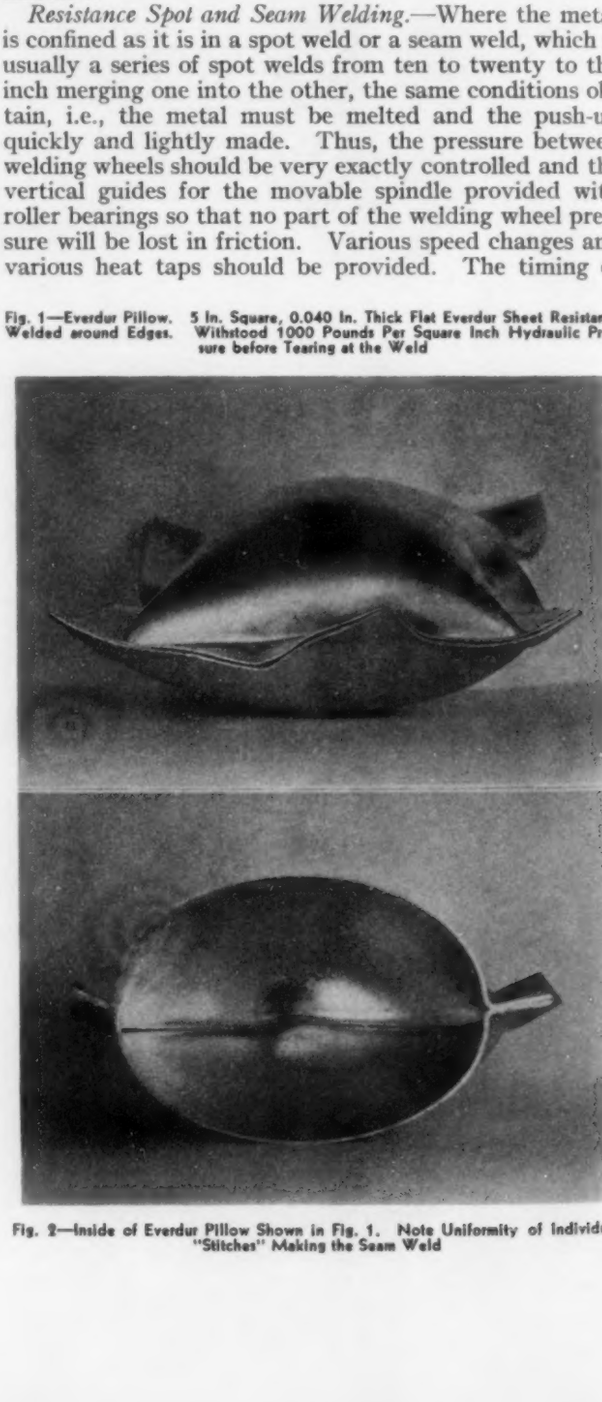


Fig. 2—Inside of Everdur Pillow Shown in Fig. 1. Note Uniformity of Individual "Stitches" Making the Seam Weld

* A paper read at the annual meeting of the AMERICAN WELDING SOCIETY, Chicago, October 3, 1935.

† Research Engineer, The American Brass Co., Waterbury, Conn.

[1] All copper alloys do not have this hot short range but many of the more important ones do.

the heat pulses may be effected mechanically or better still by the use of thyratron tubes or a photoelectric cell.

Owing to the high electrical and thermal conductivity of the low zinc brasses, commercial bronzes and beryllium coppers a capacity of 150 kva. is usually required. With the Everdurs, aluminum bronzes, phosphor bronzes, common brasses, silicon brasses, nickel silvers and cupronickels which have lower heat and electrical conductivities, a lower capacity machine will be found satisfactory.

Since the welding operation is not accompanied by a chemical change, the short-time heat pulses so necessary with some of the ferrous metals are not so essential with most of the copper alloys. However, a short heat-on period is desirable on the precipitation hardening alloys such as beryllium copper in order to avoid softening of the metal around the weld. Moreover, fast welding speeds are beneficial in such alloys as the Everdurs and the silicon brasses as the quick freezing results in a finer grain.

Copper Alloys Discussed.—Of the many hundreds of copper alloys we may cite those listed in Table 1 as being representative.

It will be noted that these representative copper alloys have been roughly arranged in the order of their resistance weldability. It will be noted further that this arrangement is approximately inversely proportional to the electrical conductivity. Thus the Everdurs with very low conductivities are at the head of the list for resistance welding and pure copper with an electrical conductivity of 100% is regarded as the poorest metal for resistance welding.

As would be expected the thermal conductivity parallels the electrical conductivity quite closely. It is the combined effect of these two properties that makes copper and the high conductivity alloys so difficult to resistance weld rather than any inherent difficulty in getting the metal to flow together. Thus the low electrical resistivity means low heat for a given kva. and even this low heat is largely conducted away by the surrounding metal. Heat pulses of short duration (and therefore of high intensity) help to minimize the heat loss due to the high thermal conductivity of the metal. Projection welding in copper sheet could probably be accomplished without d fficulty, were there 200 kva. available at the electrodes and the heat pulses were made sufficiently short.

Effect of Alloying Elements.—Since pure copper is not readily weldable by resistance methods, we are interested in determining what alloying elements in copper are most effective in producing a satisfactory sheet metal suitable for resistance welding. At the top of the list we note the three Everdur alloys with three nickel alloys all in the "excellent" resistance welding class. We see further that there are only four alloying elements, (1) manganese, (2) zinc, (3) silicon and (4) nickel.

Briefly stated, the rôle these four elements play in the copper alloy as they are related to the development of a high strength, resistance weldable sheet is as follows:

Manganese.—This element generally forms a solid solution with copper. Alone with copper, however, it does not make an alloy of any great value. It confers little strength and ductility; at fusion welding heats, it causes the alloy to spit and swell; its oxide is closely clinging and interfering with the metal flow though, as it is not very refractory, it does not interfere with welding operations as do the refractory oxides of aluminum and beryllium.

In small proportions usually under $1^1/_2$%, manganese exerts its greatest benefit on copper alloys as a deoxidizer and desulphurizer. In fusion welding, the manganese oxide tones down the oxides of silicon and copper to make a low melting, flux-like glass which spreads over the molten metal in a transparent impervious film protecting it from the hot gases and further oxidization.

In resistance welding manganese helps very little. It depresses the electrical and thermal conductivity of the alloy of course but not as much as do some other elements as, for instance, silicon and phosphorous. However, it offers no handicap and it is beneficial as a deoxidizer as was pointed out above.

Zinc.—Without a doubt, zinc is the most important alloying element of copper making as it does the series of brasses with their great variety of properties useful and beautiful. Zinc deoxidizes the copper, strengthens and, in certain proportions, improves the ductility and resilience.

The brasses have melting points lower than that of copper and in fusion welding, they flow freely with a bright surface. The one short-coming of the brasses is due to the high volatility of the zinc. Pure zinc melts at 786° F. and boils at 1706° F. Alloyed with copper, its tendency to vaporize is somewhat damped but increases rapidly when the brass is heated above its melting point. Immediately the vapor is free of the surface of the molten metal it burns to the familiar white oxide of zinc.

Under the direct action of the electric arc, the vapor pressure of the zinc is so great and the obscuring action of the resulting zinc oxide smoke so bad as to make welding of the brasses by these processes practically impossible. With the oxyacetylene torch the temperature of the molten metal can be kept down, and consequently, the volatilization of the zinc greatly reduced or suppressed entirely.

In resistance welding, the zinc helps cut the electrical and thermal conductivity of the brasses down to where the sheet can be welded by these methods. It does not, however, act fast as could be desired in this direction. Thus the red brass 80% carrying 20% zinc (and in a larger measure the 15% zinc red brass or the 10% zinc commercial bronze) which is an excellent alloy for many corrosion resisting and architectural purposes is still too high in heat and electrical conductivity to admit of its being welded with anything smaller than a 150 kva. machine. The common brasses with higher zinc contents are, as far as capacity of welding machines goes, much easier to weld than the low zinc brasses. With still higher percentages of zinc as in the muntz metals and tobin bronze, the usual resistance welding transformers have sufficient capacity but trouble is encountered on account of the tendency of the copper electrodes to "pick-up" metal from the sheet with considerable loss of time in redressing or changing electrodes.

The volatility of the zinc is also an occasional source of trouble in resistance welding. Normally the brass will weld under the spot electrodes or wheels without appreciable zinc vaporization. But if there is even a slight change in the welding conditions, as for instance a bit of scale or dirt on the electrode or between the sheets, the electrical-heat energy vaporizes the zinc momentarily, resulting in a hole in the sheets or a burnt spot on the electrode which will require redressing. With the 150 kva. used to weld the low zinc brasses, exceptional care is necessary in order to avoid such delays.

It is safe to say, therefore, that the straight copper-zinc alloys will not be found commercially practicable where gas tight resistance welded seams are desired. Where a connection of reasonable strength with an occasional imperfection in the weld is satisfactory, brass can be and is commercially weldable by resistance methods.

Silicon.—Silicon has been used as a deoxidizer of copper alloys since about 1895. It was not, however, until

after the late Mr. Chas. B. Jacobs, in 1925, patented the copper-silicon-manganese alloy, known as "Everdur," that such material became available in sheets of any desired size and thickness. The silicon and manganese in Everdur "A" make with the 96% copper a high strength, corrosion-resisting, ductile alloy which is readily hot forgeable over a wide range of temperatures and equally readily weldable by almost any method.

The silicon depresses the electrical and thermal conductivities to such an extent that resistance welding of Everdur is readily accomplished by the usual 100 kva. transformer. Copper alloyed with silicon alone forms, under fusion welding heats, a harsh, refractory scale. Modified with manganese and to a lesser extent with zinc, the scale formed at welding heats is in the nature of a thin, transparent, fusible glass. If allowed to harden, it becomes an excellent dielectric which interferes greatly with resistance welding operations. It is important, therefore, that the surfaces of silicon alloys be scrupulously clean before welding is attempted.

Nickel.—Next to silicon, nickel is the alloying element in copper contributing most to resistance weldability. Roughly, silicon is about six times as effective as nickel and ten times as effective as zinc in improving the copper alloy for resistance welding.

As is well known, nickel is soluble in copper in all proportions. Unlike manganese, it has a profound effect on the strength of the resulting alloy. It is not a deoxidizer but requires manganese, zinc, silicon or some other element to free it of oxygen and sulphur. Nickel depresses the electrical conductivity rapidly. Thus with 10% nickel and 90% copper, the conductivity is only 12% of that of pure copper while with the 70:30 cupronickel it is less than 5%. This explains in a large measure the excellent rating given the nickel-bearing copper alloys.

One might think that, since both silicon and nickel are beneficial in producing with copper good resistance weldability, an alloy carrying copper, silicon and nickel would possess exceptional advantages in this respect. This is true in general but the combination of silicon and nickel in copper produce a precipitation hardening alloy which has to be handled quite differently from the cupronickels or the silicon-copper alloys.

Nickel added to the copper-zinc alloys to form the familiar and useful series of nickel-silvers contributes to the strength, corrosion resistance and weldability with no complications such as are encountered with the nickel-silicon combination. Thus the nickel-silvers are exceptionally good resistance welding alloys.

Cupro-nickel is in some respects more difficult to fusion weld than the copper-silicon alloys. At welding heats, the closely clinging, highly refractory nickel oxide forms on the surface of the metal. This oxide is more difficult to displace or dissolve with a flux than the oxide of any of the more common metals with perhaps the exception of chromium.

Tin.—Copper alloyed with tin, the bronze of the ancient and modern times, is a very good resistance welding alloy. In point of resistance weldability, the copper-tin alloys offer less difficulty than the copper-zinc brasses. While tin by itself melts at 450° F., its boiling point is

Table 1—Properties of Copper Alloys

Name	Approximate Composition* %		Melting Point Deg. C.	Melting Point Deg. F.	Conductivity Elec. % I.A.C.S.	Conductivity Heat[a]	Tensile Strength PSI Soft	Tensile Strength PSI Cold Rolled	Resistance Weldability Rating
	Mn	*Si*							
Everdur A	1	3	1019	1866	6.7	0.08	56000	90000	A
	Zinc								
Everdur 1040	1	3	1020Δ	1868Δ	7.9	0.09Δ	56000	85000	A
Everdur 1027	...	...	995Δ	1823Δ	14.3	0.16Δ	56000	85000	A
	Nickel								
Supernickel	...	30	1225	2237	4.8	0.07	60000	90000	A
Ambrac A	5	20	1150	2102	6.2	0.09	50000	85000	A
Nickel-Silver A	20	18	1110	2030	5.9	0.08	58000	90000	A
	Al								
5% Al Bz	5	...	1060	1940	17.7	0.18	52000	90000	B
8% Al Bz	8	...	1040	1904	14.8	0.16	60000	100000	B
	Be								
Beryllium Cu	1.5	0.5	915	1679	17	...	70000	118000	B
Beryllium Cu Heat Treated	1.5	0.5	915	1679	23	0.20	...	180000	B
	Zinc								
Red Brass 80	20	...	1000	1832	32	0.34	43000	80000	B
	Tin								
Coe Bronze	...	10.5	1000	1832	10.6	0.12	60000	100000	B
2:1 Brass	34	...	920	1688	26.0	0.29	46000	70000	B
Muntz Metal	40	...	905	1661	28.6	0.30	55000	...	C
Tobin Bronze	40	0.75	885	1625	25.0	0.28	54000	75000	C
Red Brass 85	15	...	1020	1868	37.0	0.38	42000	70000	C
Commercial Bronze	10	...	1045	1913	41.0	0.45	37000	65000	D
	Phos.	*Oxygen*							
Deoxidized Copper	Trace	0.00	1083	1981	85	...	33000	50000	D
Copper	...	0.05	1083	1981	100	0.92	32000	50000	D

* Copper remainder in each case.
[a] Cal./cm.²/cm./sec./deg. C.
Δ Estimated.

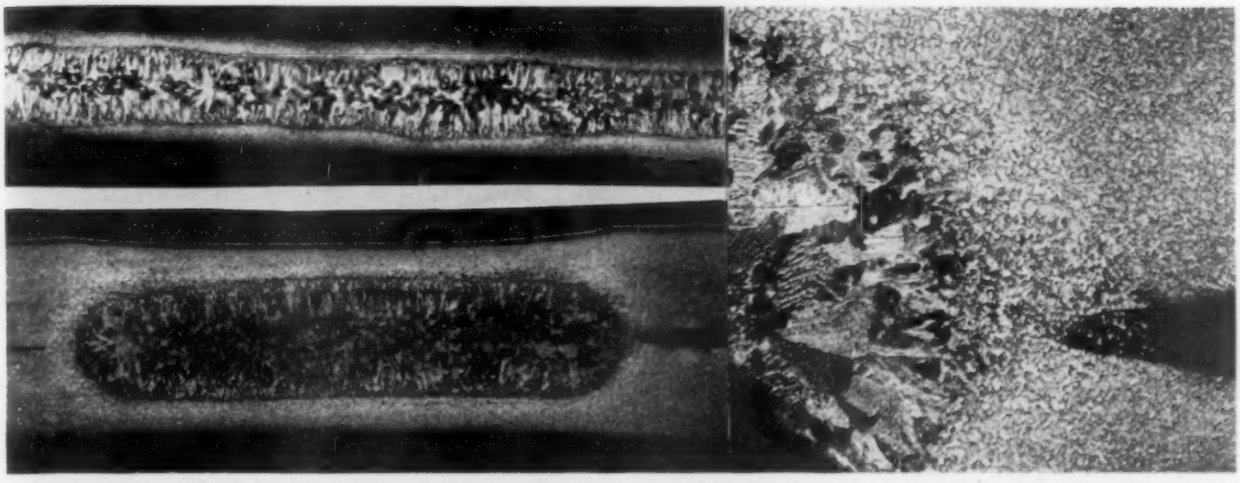


Fig. 3—Everdur "A." 0.040-In. Thick Resistance Seam Welded. (Left) Transverse Section of Weld. (Right) Large Magnification of Edge of Weld Showing Coarse Grained Weld Metal Merging into Parent Metal. (Top Left) Longitudinal Section of Weld. Unfused Outside Surfaces of Original Sheets on Top and Bottom with Continuous Weld Between. (The Dark Patches Are a Different Phase of the Weld Metal and Not Voids.) Same as Welds in Figs. 1 and 2

very high, being 4100° F. Hence, there is no trouble due to volatilization as there is with zinc.

In fusion welding, the copper-tin alloys melt with a bright surface and what little oxide forms is easily fluxed off. The metal is, however, more or less hot short and precautions must be taken to avoid hot working the metal too much in welding operations or offering restraint to its shrinkage from a fusion heat.

The copper-tin alloys require a deoxidizer. Zinc is sometimes used but phosphorous, being more active, is more common. Hence, the name "Phosphor Bronze."

Phosphorous.—The addition of phosphorous to the tin-bronzes or to copper alone is beneficial for a resistance welding material in that it depresses the electrical conductivity very rapidly. However, in the small percentages in which it can be used, 0.03 to 0.50%, it contributes little to the strength. In larger proportions, phosphorous cuts the ductility of the copper alloy too much.

Moreover, phosphorous in any appreciable amount increases the tendency of the copper electrodes to "pick-up" metal from the sheet. Hence, it is unlikely that phosphorous will ever play a greater rôle in resistance welding alloys than that of a deoxidizer.

Aluminum.—The aluminum-copper alloy, known as "aluminum bronzes" may in some future time occupy a higher place than is accorded them in Table 1. They have good ductility hot and cold, moderate annealed strength responding rapidly to cold work and very good resistance weldability.

The aluminum bronzes retain their hardness up to red heat better than most copper alloys. Furthermore, on being heated the aluminum forms a thin, almost colorless, closely clinging oxide on the surface of the metal which protects it from further oxidization. It, therefore, remains bright after long periods of heating.

The resistance weldability of the 5% and the 8% aluminum bronzes is very good. The electrical conductivities are higher than for the silicon-copper alloys but they are still low enough to make it possible to weld such sheet with the usual welding transformers. The coating of aluminum oxide is not thick enough to seriously interfere with the resistance welding of the 5% alloy and even with the 8% alloy it gives little trouble. In oxyacetylene welding, however, the aluminum oxide film does interfere with the flow of the metal particularly with eight or more per cent of aluminum. The 5% aluminum bronze can, however, be satisfactorily welded with the torch or the arc.

Beryllium.—This element alloyed with copper to the extent of $1\frac{1}{2}$ to 2% has a profound influence on the tensile strength, hardness, resilience and rigidity of the metal. The tensile strength of the soft metal is 70,000 pounds per square inch with a high degree of ductility. In this condition, it can be cold worked or shaped to any required extent. A precipitation heat of 275° C. (527° F.) will increase the strength greatly. Thus with cold rolling followed by the precipitation treatment a tensile strength of 190,000 pounds per square inch may be developed.

In a manner quite similar to the aluminum in aluminum bronze, a thin closely clinging oxide of beryllium will form on the surface of beryllium copper when the metal is heated. This oxide is extremely refractory and insoluble in most fluxes. Hence, oxyacetylene fusion welding of this material is practically out of the question, though, by keeping the metal covered with flux, satisfactory brazing and silver soldering can be done.

The beryllium copper may be carbon arc welded if the operation be carried on at sufficient speed to forestall interference from the beryllium oxide. As an illustration, we found that by using a $\frac{5}{16}$-in. diameter carbon electrode with a current of 225 amperes and an arc length of $\frac{1}{8}$ to $\frac{1}{4}$ in. melting a $\frac{5}{32}$-in. diameter beryllium copper welding rod at approximately 1 in. of rod per inch of weld, we could obtain an excellent weld in $\frac{1}{8}$ in. thick beryllium copper sheet. The edges were given a 45° bevel to make a 90° single vee groove. The plates were clamped to a copper backer. No flux was required. The metal flowed together under the thin, tough, refractory skin of beryllium oxide with excellent soundness and strength. Welded strengths of 160,000 pounds per square inch have been obtained by this method in a peened and heat-treated sample which is, we believe, the highest strength obtained to date in a copper alloy fusion weld.

Starting with the clean metal, beryllium copper can be readily resistance welded. While placed in the order of second preference for resistance welding, further work may enable one to give it an "excellent" rating. Thus there are a number of different conditions in which the metal can be welded, (1) in soft, annealed state, (2) in the cold rolled condition, (3) after annealing and heat treating or (4) after cold rolling and heat treating. Similarly the assembly may be annealed and heat treated after welding or simply given the precipitation heat. Ordinarily a resistance weld cannot be cold worked though such treatment would be beneficial.

Only a few of these procedures have been evaluated for resistance welding to date.

Cold Work and Welded Strength.—With the single exception of beryllium copper, the strength and hardness of the copper alloys given in Table 1 can only be increased by cold work—in the case of sheet metal by cold rolling. For the most part, these cold rolled metals begin to soften at 300° C. (572° F.). Hence, any joining process where a spreading heat is used will soften the metal and the connection will be no stronger than that of the annealed sheet. Soft solder by reason of the low temperature of its application is the only exception.

In the case of resistance seam and spot welding, however, where the heat can be sharply localized and the welding operation accomplished in extremely brief periods, a measure of the cold work strength can be retained even though the weld itself reaches the 2000° F. temperature necessary for proper fusion.

In Table 2 we have listed the strengths developed by resistance welded connections in soft and cold rolled copper alloy sheets. These values are to be regarded as minimum rather than maximum since many of the welds were made on machines having insufficient capacity and inadequate time control.

The values given in the second of the tensile strength columns were obtained on test specimens cut from the welded sheet as illustrated in Fig. 4. Thus the weld itself is in shear. With a weld of adequate shearing area, the weakest section is at the edge of the weld where the direct tension is combined with a certain amount of bending stress. The latter stress is not great when the sheets are relatively thin.

It will be noted in the case of Everdur A, Ambrac and

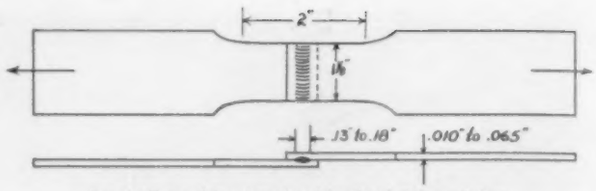


Fig. 4—Type of Specimen Used for Welded Strength Test

supernickel where we have tests on both the annealed and cold rolled materials, that an appreciable amount of the cold work strength is retained in the welded connection. It is possible to do this as the weld made, of a series of spots, is vignetted into the base metal. A still higher per cent of the cold work strength could, of course, be retained if additional seams were run with a wider pitch of spots (thus leaving cold worked metal between them) as in a riveted connection.

As will be seen from Figs. 3 and 5, the entire thickness of the sheet is not recrystallized and, therefore, not annealed by the welding heat. Further, the failure in tension is at the edge of the weld (end of the transverse section, Figs. 3 and 5) where a considerable part of the fracture must occur in the original cold worked material. Hence an appreciable part of the cold rolled strength is retained in the welded seam.

We believe it is possible to retain a still higher proportion of the cold work strength if the welding variables are pointed to this end. For instance, if the welding time were shortened, it should be possible to make the depth of the weld a smaller proportion of the thickness of the sheet without diminishing its width. With thyratron control, it is possible to cut the time to one wave of

Table 2—Tests of Resistance Welds in Copper Alloys

Alloy	Condition	Thickness Inch	Tensile Strength PSI Original Sheet	Tensile Strength PSI Weld in Gage Length	Efficiency of Weld %
Everdur A	Annealed	0.064	57450	56180	97.8
Everdur A	Annealed	0.040	56550	57400	100
Everdur A	Annealed	0.020	63550	61030	96
Everdur A	Cold Rolled	0.064	94850	67470	71
Everdur A	Cold Rolled	0.040	103000	73500	71
Everdur A	Cold Rolled	0.020	85500	63050	74
Everdur 1040	Annealed	0.040	65000	64350	99
Everdur 1027	Annealed	0.040	61150	59130	97
Supernickel	Annealed	0.010	57850	58900	100
Supernickel	Cold Rolled	0.040	83000	73990	89
Supernickel	Annealed	0.010 to 0.040	57850	58500	100
Ambrac A	Cold Rolled	0.067	76970	59300	77
Ambrac A	Cold Rolled	0.041	77500	64350	83
Ambrac A	Cold Rolled	0.020	77500	64000	83
Nickel Silver A	Annealed	0.052	60600	60450	100
5% Al Bz	Annealed	0.035	63330	60860	94
80:20 Low Brass	Annealed	0.050	43650	43825	100
2:1 Brass	Annealed	0.040	48000	47550	99
60:40 Brass	Annealed	0.050	61900	50960	82
Beryllium Copper	Cold Rolled	0.015	119680	85570	72
Beryllium Copper	Cold Rolled	0.036	118430	61800	52
Beryllium Copper	Heat treated after welding	0.015	183750	130130	71
Beryllium Copper	Heat treated after welding	0.036	190950	77530	41

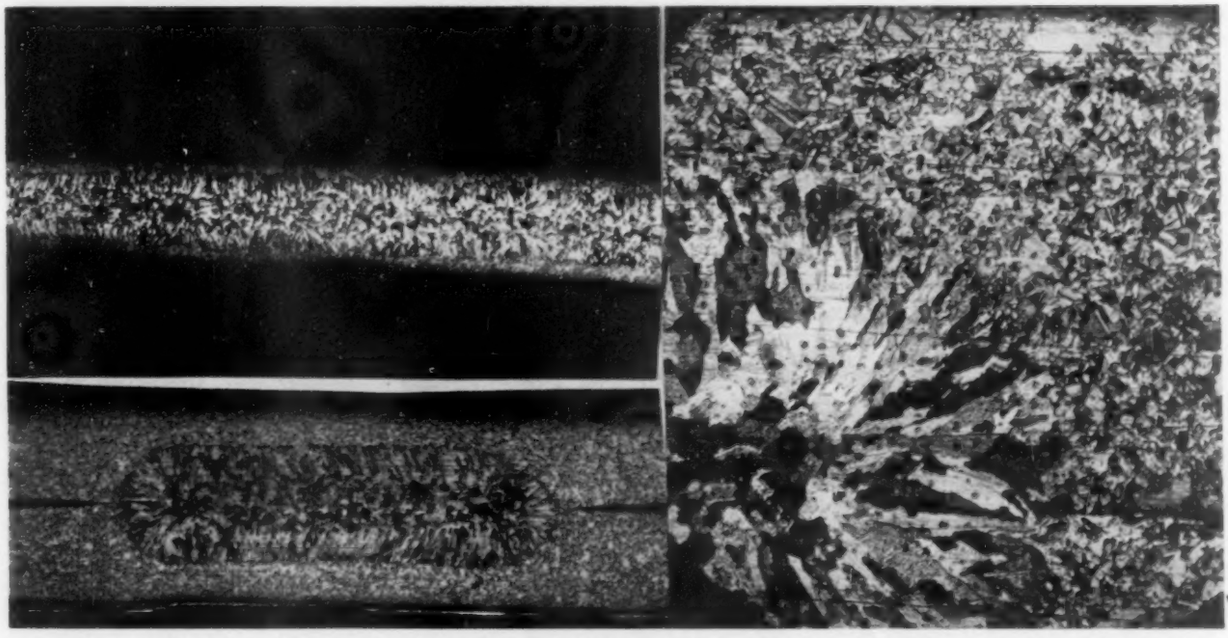


Fig. 5—Resistance Weld in 0.040 In. Thick Everdur No. 1027 Sheet. (Lower Left) Transverse Section. (Right) Extreme Edge of Transverse Section in Higher Magnification. (Left Above) Longitudinal Section

a 60-cycle current or $^1/_{120}$ second, provided the transformer has sufficient capacity to supply the requisite heat energy.

Another variable that can be controlled is the contact resistance of sheet to sheet and sheets to electrodes. If the former is made high and the latter low, the necessary heat intensity will be reached on the inner or welding surfaces while the outer surfaces are kept cool by contact with the copper electrodes. Thus, if the inner surfaces are given a thin coating of nickel or tin while the outer surfaces are left bare, the higher resistance of the coated surfaces should serve to localize the heat where it is wanted. Perhaps some coating other than that of these two metals will give still better results.

The third variable which is readily controlled is the pressure. In this case, we cannot go to extremes. There is an optimum which we must find by actual trial. If the pressure is too heavy, too much current is required, the metal is indented too much, the electrodes are squashed out too much and the weld metal is likely to be squirted in thin slivers between the sheets. If it is too light, too much heat is developed at the electrode contact and variations in pressure due to weight of sheet, buckles in sheet and inequalities in sheet surface bear too great a proportion to the total pressure. The pressure found most suitable for the copper alloys in thicknesses from 0.010 to 0.065 varies from 200 to 500 pounds. It is only about half as great as that most frequently used for steel.

In the case of continuous seam welding, the number of welds per inch of seam also has an optimum value. Thus, if the spots are too far apart, the narrow part of the seam midway between spots may become too narrow or be left unwelded. Ten welds per inch is near the low limit for a good weld. On the other hand if there are too many welds per inch, the metal and the rollers are hot-worked too much and the current values are excessive due to the detouring of a considerable part of the current through the finished weld. We have found that, in most cases, there should be not more than 19 or 20 welds per inch with 16 somewhere near an optimum for medium thickness sheets.

Applications of Resistance Welding.—In addition to the applications pointed out in the opening paragraphs, resistance welding offers an excellent means of making connections in copper alloys for a great variety of purposes.

Thus, the cold rolled strength and corrosion-resistance of the copper alloys can be advantageously utilized in *light weight construction* making engineering shapes such as beams, box girders, columns, struts and trusses from thin sheet metal strip drawn into simple angles, channels, etc., welded together. Many times such structures are economical by reason of their light weight and long trouble-free service.

Where a corrosion-resisting screen or grid is desired as in water works or sewage disposal works, the manufacture of well screens and floors for slow sand filter beds, keystone-shaped, rectangular or round wires can be resistance welded to the cross ribs making a very economical and rigid method of connection with no loss of metal or expense for fastenings. Reënforcing grids where a high-strength, corrosion-resisting alloy is desired, as for instance in concrete mats for river revetments, highway slabs through swampy places, tunnel lining, etc., can be made by spot welding the crossbars at each contact.

Containers of various sorts can be resistance seam welded. Range boilers, barrels, drums and cylinders can be rolled up from a cold rolled or light annealed sheet of Everdur (or nickel alloy if the corrosive condition warrants it) and the longitudinal seam resistance welded. If the sheets are sufficiently thin, the heads can also be placed flange outwardly and resistance seam welded.

Architectural designers can take advantage of the structural, time-defying and aesthetic qualities of these alloys to make assemblies for doors, window frames and sash, spandrels and side panels by means of resistance welds.

Acknowledgment.—The writer acknowledges with thanks the many courtesies of the Thomson-Gibb Electric Welding Company in the making of experimental welds and of The American Brass Company for permission to publish the results.

WELDING SOCIETY ACTIVITIES AND RELATED EVENTS

1936 Nominating Committee

The personnel of this Committee was announced by Chairman Crowe at the Fall Meeting as follows:

E. A. Doyle, Chairman (Past-President of Society)

F. M. Farmer, Electrical Testing Laboratories and past-president of A. W. S.

H. C. Boardman, Chicago Bridge & Iron Works

Everett Chapman, Lukenweld, Incorporated

A. F. Davis, The Lincoln Electric Company

I. B. Hexter, Industry and Welding

Charles Schenck, Bethlehem Shipbuilding Corp.

The appointment and announcement of the Nominating Committee at the time of the Fall Meeting provides every member of the AMERICAN WELDING SOCIETY an opportunity to indicate to members of the Nominating Committee their ideas and wishes in the selection of officers and members of the Board of Directors for the coming year. This is a privilege and at the same time a duty of every member of the Society.

1935 Fall Meeting

Without question the most successful Fall Meeting ever held in the history of the Society took place in Chicago, September 30th to October 4th. The registered attendance by the AMERICAN WELDING SOCIETY staff totaled 1140. The Chief Engineer of the City of Chicago welcomed members of the Society at the opening session and again at the Fall Meeting and Dinner.

The technical sessions were unusually well attended and the inspection trip, although held on the last day, was attended by some 75 members of the Society and their guests.

Social functions including ladies entertainment, Milwaukee Night and the Annual Banquet were well attended and contributed to the success of the meeting.

Opinion was unanimous that the Exposition was the best in the history of the Society.

The Miller Memorial Award was made to Mr. Charles A. McCune and further reference to this subject is given elsewhere.

Some 20 professors participated in the Research Conference of professors held on Tuesday evening and represented universities from Boston to San Francisco. A number of foreign visitors were present including representatives from Belgium and Sweden.

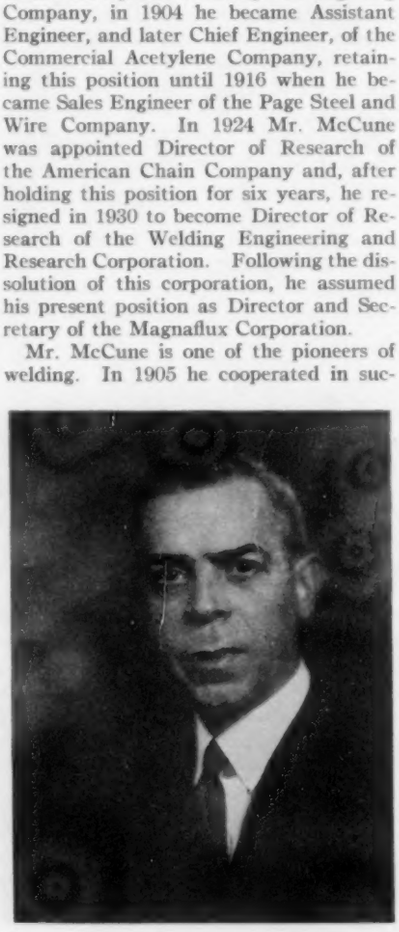
A partial list of Chicago membership participating in the annual fall meeting of the AMERICAN WELDING SOCIETY and contributing to its success are D. C. Wright, F. L. Spangler, George Horton, H. C. Boardman, E. D. Benton, L. C. Monroe, R. E. McFarland, C. D. Young, Jules Muller, C. J. McGregor, J. M. Jardine, E. V. VanDresser, R. W. Sternke, A. L. Wilson, E. L. Quinn, Gale Adams, Otto Voss, O. L. Howland, R. G. Mason, Tom Jones, T. S. Wright, W. M. B. Brady, W. M. Black, G. E. Tenney, Dana Summers, Fred Walters, L. M. Strope, M. M. Weist.

Presentation of Samuel Wylie Miller Memorial Medal for the Year Nineteen Hundred and Thirty-four to Charles A. McCune at the Fall Meeting of the American Welding Society, September 30, 1935

Charles Andrew McCune, born in Jersey City October 17, 1879, received his education in general science at Cooper Union, New York City. Married at the age of 22, he is the father of four children.

From the position of Chief Draftsman of the Safety Car Heating and Lighting Company, in 1904 he became Assistant Engineer, and later Chief Engineer, of the Commercial Acetylene Company, retaining this position until 1916 when he became Sales Engineer of the Page Steel and Wire Company. In 1924 Mr. McCune was appointed Director of Research of the American Chain Company and, after holding this position for six years, he resigned in 1930 to become Director of Research of the Welding Engineering and Research Corporation. Following the dissolution of this corporation, he assumed his present position as Director and Secretary of the Magnaflux Corporation.

Mr. McCune is one of the pioneers of welding. In 1905 he cooperated in successfully developing the type of cylinders used today for the safe storing and transportation of acetylene, and in devising other safety devices. With the Page Steel and Wire Company he actively continued his early investigations in the field of welding rods and electrodes for both gas and arc welding. As a member of the Emergency Fleet Welding Committee he was chiefly responsible for the crystallizing of specifications for these products.



Mr. McCune is one of the founders of the AMERICAN WELDING SOCIETY, and since the year 1919 he has served as Chairman of its Committee on Filler Metal Specifications. In 1922 he was elected to the office of President of the Society, and during his tenure he was active in organizing its local sections. From 1923 until the present time he has been Treasurer of the Society. He has also served as a member of previous Boards of Trustees for the award of the Samuel Wylie Miller Memorial Medal.

Mr. McCune has held the office of President of the International Acetylene Association, and for two years he served as Chairman of the Morehead Medal Award Board, and as Chairman of the Acetylene Development Committee of that association. He is a member of the American Society of Mechanical Engineers, the American Society for Testing Materials and the Advisory Board of the United States Bureau of Standards.

Mr. McCune is the author of numerous papers on acetylene and its uses, the metallurgy of welding rods and welds, the manufacture of iron and steel wire and research methods in iron and steel production. He has collaborated with other authors in the preparation of articles on gases, metallurgy and welding. He has cooperated in successfully developing practical means for locating defects in metals by magnetic methods of testing.

The AMERICAN WELDING SOCIETY owes much to "Charlie" McCune for his steadfast promotion of modern welding processes as well as for his able handling of its financial affairs. He was a close and esteemed personal friend of "Sam" Miller, and it is difficult to imagine a recipient who would be more acceptable to the man in whose memory the award is perpetuated.

For these reasons, as Chairman of the Board which made this award, I take peculiar satisfaction in now having the honor of presenting the Samuel Wylie Miller Memorial Medal for the year 1934, together with the accompanying certificate of award, to Charles A. McCune, in recognition of "his pioneering in the development and application of fusion welding."

F. T. LLEWELLYN,
Chairman, Board of Trustees
Samuel Wylie Miller Memorial Medal

Notice of Public Hearing

The Aldermanic Committee on Buildings will hold a public hearing on Article 8 of the proposed new Building Code covering Construction on Thursday, October 31, 1935, at 2 P.M., in the Aldermanic Chamber, City Hall.

THE MERCHANT'S ASSOCIATION
OF NEW YORK

New Edition of Arc Welding Handbook

A revised and enlarged edition of Procedure Handbook of Arc Welding Design and Practice is announced by The Lincoln Electric Company.

The present volume is some 140 pages larger than the preceding one. Encyclopedic in scope and contents, the new Handbook contains 586 pages, divided into eight principal sections which deal with an important phase of arc welding. The text is written in a simple, concise manner and is profusely illustrated, there being over 700 illustrations consisting of detailed drawings and photographs. Practically every use and application of arc welding is covered.

New features added to the book include the following: AMERICAN WELDING SOCIETY specifications for filler metal; method of determining the amount of current carried by the electrode; procedures, speeds and costs for making all types of welds in sheet metal; A. S. M. E. Boiler Code requirements for butt welds in heavy plate; hard facing of ferrous metals; examples of redesigning for arc welding; use of arc welding in making and repairing cutting tools and dies; speed of welding oil and gas pipe lines, etc.

Written especially for the use of designers, engineers, welding supervisors and operators, the Procedure Handbook serves as a practical guide to all who are interested in arc welding. It also serves as a handy reference for estimating welding costs.

The eight sections of the book cover the following subjects: Part I—Welding Methods and Equipment; Part II—Technique of Welding; Part III—Procedures, Speeds and Costs for Welding Mild Steel; Part IV—Structure and Properties of Weld Metal; Part V—Weldability of Metals; Part VI—Designing for Arc-Welded Steel Construction of Machinery; Part VII—Designing for Arc-Welded Structures; Part VIII—Typical Applications of Arc Welding in Manufacturing, Construction and Maintenance; Part IX—Advertising Section.

The new Handbook is 5¾ x 9 inches, suitable for desk or shop use. It is bound in semi-flexible simulated leather, embossed in gold. Copies may be obtained through the AMERICAN WELDING SOCIETY and will be sent to any address in the United States for $1.50 per copy. Foreign postage fifty cents additional.

Pamphlet

"Automatic Arc Welding by the Electronic Tornado." A very handsomely illustrated pamphlet has just been issued by the Lincoln Electric Company of Cleveland, Ohio, showing the various products manufactured by the Automatic Arc Welding process. The process itself is described and data given on the physical properties and cost of welding by this method.

SECTION ACTIVITIES

BOSTON

The first meeting of the season will be held on Friday, October 18th, in Room 4-270 at the Massachusetts Institute of Technology. Mr. W. L. Warner of the Watertown Arsenal will speak on "The Effect of Stress-Relieving." The meeting will start at 7:30 P.M.

Other meetings being arranged for this season include a Railroad Meeting at one of the nearby Car Shops, and a meeting devoted to Submarine Welding. Further notice of these meetings will be given later.

BALTIMORE

The meeting scheduled for October 18th will be a joint meeting of the A. S. M. E. and A. W. S. Dr. J. C. Hodge of Babcock & Wilcox Company will be the speaker and his subject will be "The Basic Requirements for Making Good Welds." A large attendance is anticipated at this meeting.

PHILADELPHIA

A successful meeting of this Section was held on September 16th. Mr. H. C. Snyder of the Metal Welding Company presented an excellent paper on "Management and Profits in Welding," following which there was a lively discussion.

Mr. Hosted, Chairman of the Lecture Course Committee, to be presented under the auspices of this Section announced the names of the speakers and the dates of the Course "Five Steps to Good Welding." The following subjects will be covered:

Check of the Welders.
Selection and Inspection of Materials.
Design, Layout and Preparation for Welding.
Organization and Welding Technique.
Inspection and Tests.

PITTSBURGH

The October meeting of the Pittsburgh Section will be held on the 16th. "The Characteristics of Aluminum Alloys and the Design of Welded Aluminum Structures" will be presented by F. V. Hartman, Aluminum Company of America. "The Requirements for Electric Resistance Welding Equipment for Joining Aluminum" will be presented by D. I. Bohn, Aluminum Company of America. "Metallic Arc and Torch Welding the Aluminum Alloys" will be presented by G. O. Hodlund, Aluminum Company of America. The meeting will take place in the East Room, Roosevelt Hotel, 8:00 P.M. Slides will be used to illustrate the talks. Typical samples of welded assemblies will be on display.

SAN FRANCISCO

An "Old Timer's Night" was held on September 27th at the Athens Athletic Club, Oakland. Several Welding Equipment Manufacturers donated prizes which were awarded at the meeting. A new and interesting film of the International Acetylene Association was shown. Beer and sandwiches were served.

LOS ANGELES

The first meeting of the season was held on September 19th at the new "Times" Building. There were 110 members and guests present.

Chairman Frank Howard opened the meeting with Discussion on Membership and proposed program for getting additional members through Structural Steel Welding Course.

The meeting was given over to a complete description of the new "Times" Building.

Mr. R. H. Crawford, Associate Architect of Gordon B. Kaufman, Architect of the "Times," gave a very interesting talk on the history of the building, giving details on what was required and method followed to obtain these details.

Murray Erick, Consulting Engineer Structural Steel Design, followed with talk on earthquake design and welding of building.

Harold F. Utley of Consolidated Steel Corporation, the steel erectors of the building, gave detailed picture of method of handling such a job.

Other speakers included Mr. Lowell, Consulting Engineer, and Mr. Al Steart, Superintendent of the job.

DETROIT

Mr. R. T. Gillette of the General Electric Company will address the meeting to be held on Thursday, October 24th at the Fort Shelby Hotel, Detroit, on "Resistance Welding of Stainless Steel with Accurate Time Control." Mr. Jos. E. Geschelin, Technical Editor, Automotive Industries, will be Toastmaster.

NEW YORK

Meetings—Season 1935–36

Subjects	Dates
"Building Codes"	November 26, 1935
"Aviation"	December 10, 1935
"Power and Railroads" (Joint Meet. (A.S.M.E.))	January 1936
To Be Selected (Joint Meeting (A.S.C.E.)	February 1936
"Low Alloy High Tensile Steels and Miscellaneous Metals" (Joint Meet. (A.S.T.M.))	March 1936
"Shipbuilding"	April 14, 1936

SERVICES AVAILABLE

As–224. Position wanted as welding inspector or equipment salesman. Five years' experience as combination welder on construction, water tight and general job shop. Student of metallurgy with two years practical laboratory work.

International Acetylene Association

An announcement concerning the program of the 36th Annual Convention of the International Acetylene Association to be held in Cleveland, on November 12 to 15, 1935, is given in the advertising section. A very interesting and highly instructive program has been prepared. All members of the AMERICAN WELDING SOCIETY are cordially invited to attend all sessions.

Two Welding Clinics Planned

Educational opportunities for all persons interested in the oxyacetylene process of welding and cutting are again being offered through the medium of two welding clinics sponsored by The Linde Air Products Company. The first of these clinics will be held October 23rd, 24th, 25th, 26th in Sam Houston Convention Hall, Houston, Texas; the second, from October 30th through November 2nd, will be conducted at the Georgia School of Technology, Atlanta, Georgia.

Similar meetings held last year in Birmingham, Houston, Cleveland and New Orleans drew an attendance of over ten thousand engineers, plant executives, welding operators and others who have found these clinics the best means of obtaining authoritative information on this subject. Daily programs include individual instruction in all types of oxyacetylene welding and cutting, demonstrations of every-day applications as well as the latest developments in apparatus and techniques, discussion groups and motion pictures. Operators and students are given an opportunity to practice under the direction of men experienced in particular phases of the process; executives and engineers can freely discuss their plant maintenance and production problems with qualified experts.

Further information and detailed programs for each of these four-day clinics can be obtained by writing The Linde Air Products Company, 30 East 42nd Street, New York, N. Y., or to their sales offices in Atlanta, Birmingham, Dallas, Houston, Kansas City, Memphis, New Orleans or Tulsa.

American Inventor Heads International Committee

Dr. James F. Burke, member of the United States National Committee of the International Electrotechnical Commission, was unanimously elected president of the I. E. C. to succeed Dr. A. F. Enstrom, Sweden, at the last meeting of the plenary session of the Commission at Brussels, June 27th.

Mr. Burke for many years has been a member of the U. S. National Committee and has made valuable contributions both to the work of the U. S. N. C. and the I. E. C.

He is a past-president of the Electric Light and Power Group and is widely known as an inventor. His patents include designs for a generator winding by which three-wire service from a single machine was made possible, and a motor for operation on either A.C. or D.C. supply. He served on the U. S. National Committee as representative of N. E. M. A. from 1914 to 1930, and as representative of the A. I. E. E. from 1930 to 1932. He recently retired from the Burke Electric Company of Erie, Pa., of which he was chairman of the board, after more than 30 years as active head of the company. Mr. Burke is one of the founders of the AMERICAN WELDING SOCIETY and served for a number of years on its Board of Directors.

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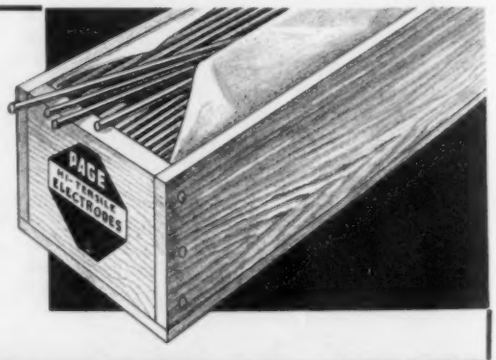

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against those of COPPER BRASS or BRONZE

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